



An Oshkosh Corporation Company

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# ***Service & Maintenance Manual***

## ***Models***

***1930ES***

***2030ES***

***2630ES***

***2646ES***

***3246ES***

**3121166**

*November 27, 2013*

***ANSI***

**CE**



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An Oshkosh Corporation Company



## SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

### A. GENERAL

This section contains the general safety precautions which must be observed during maintenance of the aerial platform. 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 that the machine is safe to operate.

#### **⚠ WARNING**

**MODIFICATION OF THE MACHINE WITHOUT CERTIFICATION BY A RESPONSIBLE AUTHORITY THAT THE MACHINE IS AT LEAST AS SAFE AS ORIGINALLY MANUFACTURED, IS A SAFETY VIOLATION.**

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

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of 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**

**SINCE THE MACHINE MANUFACTURER HAS NO DIRECT CONTROL OVER THE FIELD INSPECTION AND MAINTENANCE, SAFETY IN THIS AREA RESPONSIBILITY OF THE OWNER/OPERATOR.**

### B. HYDRAULIC SYSTEM SAFETY

It should be noted that the machines hydraulic systems operate at extremely high potentially dangerous pressures. Every effort should be made to relieve any system pressure prior to disconnecting or removing any portion of the system.

Relieve system pressure by cycling the applicable control several times with the engine stopped and ignition on, to direct any line pressure back into the reservoir. Pressure feed lines to system components can then be disconnected with minimal fluid loss.

### C. MAINTENANCE

#### **⚠ WARNING**

**FAILURE TO COMPLY WITH SAFETY PRECAUTIONS LISTED IN THIS SECTION MAY RESULT IN MACHINE DAMAGE, PERSONNEL INJURY OR DEATH AND IS A SAFETY VIOLATION.**

- ENSURE REPLACEMENT PARTS OR COMPONENTS ARE IDENTICAL OR EQUIVALENT TO ORIGINAL PARTS OR COMPONENTS.
- NO SMOKING IS MANDATORY. NEVER REFUEL DURING ELECTRICAL STORMS. ENSURE THAT FUEL CAP IS CLOSED AND SECURE AT ALL OTHER TIMES.
- REMOVE ALL RINGS, WATCHES AND JEWELRY WHEN PERFORMING ANY MAINTENANCE.
- DO NOT WEAR LONG HAIR UNRESTRAINED, OR LOOSE-FITTING CLOTHING AND NECKTIES WHICH ARE APT TO BECOME CAUGHT ON OR ENTANGLED IN EQUIPMENT.
- OBSERVE AND OBEY ALL WARNINGS AND CAUTIONS ON MACHINE AND IN SERVICE MANUAL.
- KEEP OIL, GREASE, WATER, ETC. WIPED FROM STANDING SURFACES AND HAND HOLDS.
- USE CAUTION WHEN CHECKING A HOT, PRESSURIZED COOLANT SYSTEM.
- NEVER WORK UNDER AN ELEVATED SCISSOR UNTIL PLATFORM HAS BEEN SAFELY RESTRAINED FROM ANY MOVEMENT BY BLOCKING OR OVERHEAD SLING, OR SAFETY PROP HAS BEEN ENGAGED.
- BEFORE MAKING ADJUSTMENTS, LUBRICATING OR PERFORMING ANY OTHER MAINTENANCE, SHUT OFF ALL POWER CONTROLS.
- BATTERY SHOULD ALWAYS BE DISCONNECTED DURING REPLACEMENT OF ELECTRICAL COMPONENTS.
- KEEP ALL SUPPORT EQUIPMENT AND ATTACHMENTS STOWED IN THEIR PROPER PLACE.
- USE ONLY APPROVED, NONFLAMMABLE CLEANING SOLVENTS.

### REVISION LOG

**NOTE:** *All machines built before mid-year 2010 are equipped with the Sevcon-1600346 Power Module, in mid-year 2010 a new design ZAPI-1001092456 Power Module was introduced for production. ES Scissors built in the USA and Belgium may be equipped with either one of two different power modules after mid-2010. All China built machines were equipped the ZAPI-1001092456 Power Module. If power module service is required, see Section-3 in order to locate and identify which power module your machine is equipped with.*

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7-9	Power Module - J2 (1001092456 Power Module ONLY) .....	7-17

## SECTION 1. SPECIFICATIONS

## 1.1 SPECIFICATIONS

Table 1-1. Operating Specifications

Description	1930ES	2030ES	2630ES	2646ES	3246ES
Maximum Stowed Travel Grade (Gradeability)	25%	25%	25%	25%	25%
Maximum Stowed Travel Grade (Sideslope)	5°	5°	5°	5°	5°
Maximum Platform Height	18.75 ft. 5.7 m	20 ft. 6 m	25.8 ft. 7.75 m	26 ft. 7.9 m	32 ft. 9.8 m
Maximum Tire Load: ANSI: CE:	1365 lb (620 kg) 1540 lb (699 kg)	1660 (755) 1835 lb (832 kg)	1835 lb (832 kg) 1835 lb (832 kg)	2070 lb (939 kg) 2320 lb (1052 kg)	2070 lb (939 kg) 2320 lb (1052 kg)
Ground Bearing Pressure (ANSI)	109 psi (7.7 kg/cm <sup>2</sup> )	81 psi (5.7 kg/cm <sup>2</sup> )	90 psi (6.3 kg/cm <sup>2</sup> )	87 psi (6.1 kg/cm <sup>2</sup> )	87 psi (6.1 kg/cm <sup>2</sup> )
Ground Bearing Pressure (CE)	8.7 kg/cm <sup>2</sup> (123 psi)	6.3 kg/cm <sup>2</sup> (90 psi)	6.3 kg/cm <sup>2</sup> (90 psi)	6.9 kg/cm <sup>2</sup> (98 psi)	6.9 kg/cm <sup>2</sup> (98 psi)
Maximum Drive Speed	3 mph (4.8 kmh)	3 mph (4.8 kmh)	2.75 mph (4.4 kmh)	2.5 mph (4 kmh)	2.5 mph (4 kmh)
Maximum Wind Speed	28 mph (12.5 m/s) (Depending on model, market, and indoor/outdoor selection, see Table 1-2, Platform Capacities)				
Maximum Horizontal Manual Side Force: ANSI/CSA: ANSI/CSA (Indoor): ANSI/CSA (Outdoor): ANSI/CSA (Zone A): ANSI/CSA (Zone B): CE (Indoor): CE (Outdoor): AUS (Indoor): AUS (Indoor Zone A): AUS (Indoor Zone B): AUS (Outdoor): AUS (Outdoor Zone A): AUS (Outdoor Zone B):	100 lb force (445 N) N/A N/A N/A N/A 90 lb force (400 N) 45 lb force (200 N) 90 lb force (400 N) N/A N/A 45 lb force (200 N) N/A N/A	120 lb force (533 N) N/A N/A N/A N/A 90 lb force (400 N) 45 lb force (200 N) 90 lb force (400 N) N/A N/A 45 lb force (200 N) N/A N/A	N/A N/A N/A 120 lb force (533 N) 100 lb force (445 N) 90 lb force (400 N) N/A N/A 90 lb force (400 N) 90 lb force (400 N) N/A N/A N/A	150 lb force (667 N) N/A N/A N/A N/A 90 lb force (400 N) 90 lb force (400 N) 90 lb force (400 N) N/A N/A 90 lb force (400 N) N/A N/A	N/A N/A N/A 150 lb force (667 N) 105 lb force (467 N) 90 lb force (400 N) 45 lb force (200 N) N/A 90 lb force (400 N) 90 lb force (400 N) N/A N/A 45 lb force (200 N)
Maximum Hydraulic Pressure	1800psi	1800 psi	1700 psi (single) 1850 psi (dual)	2000 psi	2000 psi
Inside Steer Angle	90°	90°	90°	90°	90°
Outside Steer Angle	69°	73°	73°	67°	67°
Electrical System Voltage (DC)	24V	24V	24V	24V	24V
Approximate Gross Machine Weight - ANSI/CSA	2685 lbs	3830 lbs	4815 lbs	4945 lbs	4945 lbs
Approximate Gross Machine Weight - CE/Australia	1495 kg	2063.8 kg	2197.7 kg	2705.7 kg	2871.2 kg
Ground Clearance with pot hole protection system up	3.5 in (8.9 cm)				
Ground Clearance with pot hole protection system down	1 in (2.5 cm)	0.75 in (1.9 cm)			

## SECTION 1 - SPECIFICATIONS

### Capacities

**Table 1-2. Platform Capacities**

**NOTE:** All platform extension capacities are 250 lbs (120 kg)

Model	ANSI/CSA		CE INDOOR		CE OUTDOOR		AUSTRALIAN INDOOR		AUSTRALIAN OUTDOOR	
	Max Capacity	Max Persons	Max Capacity	Max Persons	Max Capacity	Max Persons	Max Capacity	Max Persons	Max Capacity	Max Persons
1930ES	500 lbs (227 kg)	2	230 kg	2	120 kg	1	230 kg	2	120 kg	1
2030ES	800 lbs (363 kg)	2	360 kg	2	160 kg	1	360 kg	2	160 kg	1
2630ES single cap	500 lbs (227 kg)	2	230 kg	2	N/A	N/A	230 kg	2	N/A	N/A
2630ES dual cap to 20 ft	800 lbs (363 kg)	2	360 kg	2	N/A	N/A	360 kg	2	N/A	N/A
2630ES dual cap to 26 ft	500 lbs (227 kg)	2	230 kg	2	N/A	N/A	230 kg	2	N/A	N/A
2646ES	1000 lbs (454 kg)	2	450 kg	2	230 kg	2	450 kg	2	230 kg	2
3246ES to 26 ft	1000 lbs (454 kg) Zone A	2	450 kg	2	320 kg	1	450 kg	2	320 kg	1
3246ES to 32 ft	700 lbs (317 kg) Zone B	2	320 kg	2	320 kg	1	320 kg	2	320 kg	1

### Fluid Capacities

**Table 1-3. Fluid Capacities**

Description	1930ES	2030ES	2630ES	2646ES	3246ES
Hydraulic Tank	2 Gal (7.6L)	2 Gal (7.6L)		3 Gal (11.3L)	
Hydraulic System (Including Tank)	2.2 Gal (8.3L)	2.8 Gal (10.6L)		5.3 Gal (19.9L)	

## Tires

**Table 1-4. Tire Specifications**

Description	1930ES	2030ES	2630ES	2646ES	3246ES
Size	323mm x 100mm	406 mm x 125 mm			
Max Tire Load	2500 lbs (1134 kg)	4000 lbs (1814 kg)			
Wheel Bolt Torque	105 - 120 ft lb (142-163 Nm)				

## Batteries

### 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.**

## Motors

### Drive Motor

Type: Shunt Wound, Sepex 24V DC

Power: 0.65 Horsepower @ 3750 rpm

### Hydraulic Pump/Electric Motor Assembly (All Models)

Type: Series Wound Permanent Magnet 24V DC

Power: 3kW

## Battery Charger

20 Amp SCR

110/250 Volts AC - 50/60 Hz input

24 Volts DC - 20 Amp output w/auto timer

### Japanese Specification

100/200 Volts AC - 50/60 Hz input

24 Volts DC - 20 Amp output w/auto timer

## SECTION 1 - SPECIFICATIONS

### Travel Speed

**Table 1-5. Travel Speed**

Model	Elevated Speed				Maximum Speed				
	Unit of Measure	Mph	Sec/25 ft	Kph	Sec/7.6 m	Mph	Sec/25 ft	Kph	Sec/7.6 m
1930ES		0.5	28-37	0.8	33-38	3	5.5-6.2	4.8	5.5-6.2
2030ES		0.5	28-37	0.8	33-38	2.75	6.18-6.6	4.4	6.18-6.6
2630ES		0.5	28-37	0.8	33-38	2.75	6.18-6.6	4.4	6.18-6.6
2646ES		0.5	28-37	0.8	33-38	2.5	7-8	4	7-8
3246ES		0.5	28-37	0.8	33-38	2.5	7-8	4	7-8

### Lift Speed (No Load in Platform)

**NOTE:** No load in platform on measured lift speeds.

**Table 1-6. Lift Speed**

Model	Lift Up (Seconds)	Lift Down (Seconds)
1930ES	18-23	25-35
2030ES	25-32	35-45
2630ES	28-38	35-40
2646ES	38-45	45-55
3246ES	50-60	58-66



## Model Dimensions

Table 1-7. Dimensions

Model	1930ES	2030ES	2630ES	2646ES	3246ES
Platform Height - Elevated	18.75ft (5.7m)	20ft (6m)	25.8ft (7.9m)	26ft (7.9m)	32ft (9.8m)
Platform Height - Stowed	2.9ft (0.9m)	3.6ft (1.1m)	4ft (1.2m)	4ft (1.2m)	4ft (1.2m)
Working Height	25ft (7.6m)	26ft (7.9m)	32ft (9.8m)	32ft (9.8m)	38ft (11.6m)
Overall Stowed Machine Height - Rails Up	6.5ft (2m)	7.2ft (2.2m)	7.7ft (2.3m)	7.7ft (2.3m)	7.7ft (2.3m)
Overall Stowed Machine Height - Rails Collapsed	N/A	6ft (1.8m)	6.4ft (1.9m)	6.4ft (1.9m)	6.4ft (1.9m)
Rail Height (From platform floor)	3.6ft (1.1m)	3.6ft (1.1m)	3.6ft (1.1m)	3.6ft (1.1m)	3.6ft (1.1m)
Overall Machine Width	2.5ft (0.8m)	2.5ft (0.8m)	2.5ft (0.8m)	3.7ft (1.2m)	3.7ft (1.2m)
Overall Machine Length - Deck Retracted	6ft (1.9m)	7.5ft (2.3m)	7.5ft (2.3m)	8.2ft (2.5m)	8.2ft (2.5m)
Overall Machine Length - Deck Extended	9ft (2.8m)	10.5ft (3.2m)	10.5ft (3.2m)	12.4ft (3.8m)	12.4ft (3.8m)
Platform Size - Length	6.1ft (1.9m)	7.5ft (2.3m)	7.5ft (2.3m)	8.2ft (2.5m)	8.2ft (2.5m)
Platform Size - Width	2.5ft (0.8m)	2.5ft (0.8m)	2.5ft (0.8m)	3.7ft (1.1m)	3.7ft (1.1m)
Platform Extension Length	3ft (0.9m)	3ft (0.9m)	3ft (0.9m)	4.2ft (1.3m)	4.2ft (1.3m)
Wheelbase	5.3ft (1.6m)	6.2ft (1.9m)	6.2ft (1.9m)	6.9ft (2.1m)	6.9ft (2.1m)

## SECTION 1 - SPECIFICATIONS

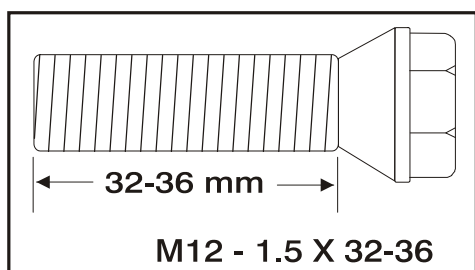
### 1.2 TORQUE REQUIREMENTS

Self locking fasteners, such as nylon insert and thread deforming locknuts, are not intended to be reinstalled after removal. Always use new replacement hardware when installing locking fasteners..

**Table 1-8. Torque Requirements**

Description	Torque Value (Dry)	Interval Hours
Rear Wheel Spindle Nut	30-40 ft lb (40-54 Nm)	50
Wheel Bolts	105-120 ft lb (142-163 Nm)	50

**NOTE:** Anytime a wheel bolt is replaced, be sure one of the same length is used. Use bolt shown below on wheels that use the 1/4" (6.4mm) ring.



**NOTE:** After tightening the spindle nut to the proper torque, loosen completely until you can turn by hand. Finger tighten nut by hand without rotating hub. Install cotter pin by backing nut off, if necessary, in order to line up slot.

When maintenance becomes necessary or a fastener has loosened, refer to Section 1.8, Torque ChartS to determine proper torque value.

### 1.3 LUBRICATION

#### Hydraulic Oil

**NOTE:** Hydraulic oils must have anti-wear qualities at least to API Service Classification GL-3, and sufficient chemical stability for mobile hydraulic system service. JLG Industries recommends DTE 11M hydraulic oil.

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 DTE 11M is desired, contact JLG Industries for proper recommendations.

**Table 1-9. Hydraulic Oil**

Hydraulic System Operating Temperature Range	SAE Viscosity Grade
0°F to +23°F (-18°C to -5°C)	10W
0°F to 210°F (-18°C to +99°C)	10W-20, 10W-30
50°F to 210°F (+10°C to +210°C)	20W-20

**Table 1-10. Lubrication Specifications**

Key	Specifications
MPG	Multipurpose Grease having a minimum dripping point of 350°F. Excellent water resistance and adhesive qualities, and being of extreme pressure 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. API service classification GL-3, e.g. DTE 11M.

**Table 1-11. Hydraulic Oil Specifications (Standard)**

Specification	MOBIL DTE 10 EXCEL 15	MOBIL EAL ENVIRONSYN 32
ISO Viscosity Grade	#15	#32
Gravity API	31.9	—
Pour Point, Max	-40°F (-40°C)	-59°F (-51°C)
Flash Point, Min.	330°F (166°C)	514°F (268°C)
<b>Viscosity Specifications</b>		
at 40°C	15 cSt	33.1 cSt
at 100°C	4.1 cSt	6.36 cSt
at 100°F	80 SUS	—
at 210°F	43 SUS	—
cp at -30°F	3.200	—
Viscosity Index	140	147

## 1.4 LIMIT SWITCHES

### Tilt Alarm

Illuminates a light on the platform, sounds an alarm and cuts out lift up and drive when the machine is out of level and above stowed depending on model and specifications.

**Table 1-12. Tilt Settings**

Model	Tilt Setting (front to back)	Tilt Setting (side to side)	Maximum Deck Elevation
1930ES	3°	1.5°	18.75 ft (5.7 m)
		2°	14 ft (4.3 m)
		2.5°	11 ft (3.4 m)
		3°	9 ft (2.7 m)
2030ES	3°	1.5°	20 ft (6 m)
		2°	15 ft (4.5 m)
		2.5°	12 ft (3.7 m)
		3°	10 ft (3 m)
2630ES	3°	1.5°	25.4 ft (7.7 m)
		2°	20 ft (6 m)
		2.5°	16 ft (4.9 m)
		3°	13 ft (4 m)
2646ES	3°	2°	26 ft (7.9 m)
		2.5°	22 ft (6.7 m)
		3°	20 ft (6 m)
3246ES	3°	2°	31.75 ft (9.7 m)
		2.5°	22 ft (6.7 m)
		3°	20 ft (6 m)

### High Drive Speed Cutout

High drive speed is cut out when the platform is raised above the preset height per model as follows:

**NOTE:** These figures are given with a tolerance of  $\pm 6$  in (0.15 m).

**Table 1-13. High Drive Speed Cutout Height**

Model	High Drive Speed Cutout
1930ES	54 in (1.4 m)
2030ES	66 in (1.7 m)
2630ES	76 in (1.9 m)
2646ES	76 in (1.9 m)
3246ES	76 in (1.9 m)

### Pressure Settings

**Table 1-14. Pressure Settings**

Model	Lift Relief	Steer Relief
1930ES	1800 psi $\pm$ 50 psi (124 bar $\pm$ 3.4 bar)	1500 psi (103 bar)
2030ES	1800 psi $\pm$ 50 psi (124 bar $\pm$ 3.4 bar)	1500 psi (103 bar)
2630ES	1950 psi $\pm$ 50 psi (134 bar $\pm$ 3.4 bar)	1500 psi (103 bar)
2646ES	2000 psi $\pm$ 50 psi (138 bar $\pm$ 3.4 bar)	1500 psi (103 bar)
3246ES	2000 psi $\pm$ 50 psi (138 bar $\pm$ 3.4 bar)	1500 psi (103 bar)

## SECTION 1 - SPECIFICATIONS

### 1.5 CYLINDER SPECIFICATIONS

**Table 1-15. Cylinder Specifications**

Description	1930ES	2030ES	2630ES	2646ES	3246ES
Lift Cylinder Bore	2.8 in (7.1 cm)	3.1 in (7.9 cm)	3.1 in (7.9 cm)	3.9 in (9.9 cm)	3.9 in (9.9 cm)
Lift Cylinder Stroke	43.2 in (108 cm)	48 in (122 cm)	48 in (122 cm)	44.9 in (114 cm)	56.8 in (144 cm)
Lift Cylinder Rod Diameter	1.8 in (4.5 cm)	2.1 in (5.5 cm)	2.1 in (5.5 cm)	2.4 in (6 cm)	2.4 in (6 cm)
Steer Cylinder (Stroke)	6.3 in (16 cm)	6.3 in (16 cm)	6.3 in (16 cm)	6.1 in (15.6 cm)	6.1 in (15.6 cm)

### 1.6 MAJOR COMPONENT WEIGHTS

**Table 1-16. Major Component Weights**

Component	1930ES	2030ES	2630ES	2646ES	3246ES
Platform	100 lbs (45 kg)	133 lbs (61 kg)		176 lbs (80 kg)	
Manual Platform Extension	45 lbs (20 kg)				
Arm Assembly - (Includes Lift Cylinder)	620 lbs (281 kg)	939 lbs (426 kg)	1,213 lbs (550 kg)	1,645 lbs (746 kg)	
Chassis w/Wheel/Tire and Drive Assembly	1,067 lbs (484 kg)	1,764 lbs (800 kg)		1,554 lbs (705 kg)	

### 1.7 CRITICAL STABILITY WEIGHTS

#### **⚠ WARNING**

**DO NOT REPLACE ITEMS CRITICAL TO STABILITY, SUCH AS BATTERIES OR SOLID TIRES, WITH ITEMS OF DIFFERENT WEIGHT OR SPECIFICATION. DO NOT MODIFY UNIT IN ANY WAY TO AFFECT STABILITY.**

**Table 1-17. Critical Stability Weights**

Component	1930 ES	2030ES	2630ES	2646ES	3246ES
Counterweight(s) (CE, AUS)	582 lbs (264 kg)	721 lbs (327 kg)		1592 lbs (722 kg)	1956 lbs (887 kg)
Counterweight (ANSI, CSA, JPN)	N/A	N/A	721 lbs (327 kg)	589 lbs (267 kg)	
Wheel and Tire Assembly (each)	22 lbs (9.8 kg)	42 lbs (19 kg)			
Wheel/Tire and Drive Assembly (each)	117 lbs (53 kg)	162 lbs (73.4 kg)			
Lift Cylinder	176 lbs (80 kg)	205 lbs (93 kg)		263 lbs (119 kg)	283 lbs (128 kg)
Batteries: (each)					
220 Amp	60 lbs (27 kg)	60 lbs (27 kg)			
220 Amp (used with Inverter/Charger)	66 lbs (30 kg)	66 lbs (30 kg)			
245 Amp	N/A	70 lbs (32 kg)			

1.8 TORQUE CHARTS

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™ OR Vibra-TITE™ 111 or 140)		Torque (Loctite® 262™ or Vibra-TITE™ 131)	
					IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
		In	Sq In	LB								
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		
		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
	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

NO. 500059 REV. J

- 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

REFERENCE JLG ANEROBIC THREAD LOCKING COMPOUND				
JLG P/N	Loctite® P/N		ND Industries P/N	Description
0100011	242™		Vibra-TITE™ 121	Medium Strength (Blue)
0100019	271™		Vibra-TITE™ 140	High Strength (Red)
0100071	262™		Vibra-TITE™ 131	Medium - High Strength (Red)

Figure 1-1. Torque Chart (SAE Fasteners - Sheet 1 of 7)

**SECTION 1 - SPECIFICATIONS**

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=.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
					IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-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		
		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
	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

NO. 500059 REV. J  
 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

Figure 1-2. Torque Chart (SAE Fasteners - Sheet 2 of 7))

SOCKET HEAD CAP SCREWS										
Magni Coating (Ref 4150701)*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .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-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
		In	Sq In	LB						
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		
		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
	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
1 1/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
1 1/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
1 3/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
1 1/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

**NO. 5000059 REV. J**

- 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 OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM  
 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.

**Figure 1-3. Torque Chart (SAE Fasteners - Sheet 3 of 7)**

**SECTION 1 - SPECIFICATIONS**

<b>SOCKET HEAD CAP SCREWS</b>										
<b>Zinc Yellow Chromate Fasteners (Ref 4150707)*</b>										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85® K=0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
					IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
		In	Sq In	LB						
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	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		
		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
	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	775	1055	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

**NO. 500059 REV. J**

- 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 OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM  
 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.

**Figure 1-4. Torque Chart (SAE Fasteners - Sheet 4 of 7)**



Values for Zinc Yellow Chromate Fasteners (Ref 4150707)							
CLASS 8.8 METRIC BOLTS CLASS 8 METRIC NUTS							
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™)	Torque (Lub)	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]	[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

**NO. 500059 REV. J**

- 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 OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM  
 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.

**Figure 1-5. Torque Chart (METRIC Fasteners - Sheet 5 of 7)**

**SECTION 1 - SPECIFICATIONS**

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)						
CLASS 10.9 METRIC BOLTS CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAP SCREWS M3 - M5*						
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™) K = 0.20	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-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	25.2	22.7	18.9
8	1.25	36.60	22.8	36.5	32.8	27.4
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

NO. 500059 REV. J

- 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 OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM  
 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.

**Figure 1-6. Torque Chart (METRIC Fasteners - Sheet 6 of 7)**

Magni Coating (Ref 4150701)*						
CLASS 12.9 SOCKET HEAD CAP SCREWS M6 AND ABOVE*						
Size	PITCH	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry or Loctite® 263™) K = .17	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K = .16	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K = .15
		Sq mm	kN	[N.m]	[N.m]	[N.m]
3	0.5	5.03				
3.5	0.6	6.78				
4	0.7	8.78				
5	0.8	14.20				
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	54
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	220.0	900	845	790
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

**NO. 500059 REV. J**

- 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 OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM  
 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.

**Figure 1-7. Torque Chart (METRIC Fasteners - Sheet 7 of 7)**

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## SECTION 2. GENERAL

### 2.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

#### 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.

#### 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 aerial work platforms. The frequency of inspections and maintenance must be increased as environment, severity and frequency of usage requires.

#### 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 Operator's and Safety Manual for completion procedures for the Pre-Start Inspection. The Operator and Safety Manual must be read in its entirety and understood prior to performing the Pre-Start Inspection.

#### 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 or 150 hours (whichever comes first); 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.

#### Annual Machine Inspection

JLG recommends that the Annual Machine Inspection 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 Factory Trained Service Technician 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.

#### 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.

Reference the Preventative Maintenance Schedule and the 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 2-1. 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 150 hours, whichever comes first; 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 (recommended)	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

**2.2 SERVICE AND GUIDELINES**

**General**

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

**Safety and Workmanship**

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of 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.

**Cleanliness**

1. 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 air, fuel, and oil supplies clean; however, these items must be maintained on a scheduled basis in order to function properly.
2. At any time when air, fuel, or 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.

3. 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.

**Components Removal and Installation**

1. 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.
2. Should it be necessary to remove a component on an angle, keep in mind that the capacity of an eye-bolt or similar bracket lessens, as the angle between the supporting structure and the component becomes less than 90°.
3. 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.

## 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.

## Pressure-Fit Parts

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

## Bearings

1. 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.
2. Discard bearings if the races and balls (or rollers) are pitted, scored, or burned.
3. 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.
4. 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.

## 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.

## Bolt Usage and Torque Application

1. Self locking fasteners, such as nylon insert and thread deforming locknuts, are not intended to be reinstalled after removal. Always use new replacement hardware when installing locking fasteners.
2. 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.

3. 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. (See Torque Chart Section 1.)

## 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.

## Hydraulic System

1. Keep the system clean. If evidence of metal or rubber particles are found in the hydraulic system, drain and flush the entire system.
2. Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components, as required, to aid assembly.

## Lubrication

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.

## Battery

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

## Lubrication and Servicing

Components and assemblies requiring lubrication and servicing are shown in the Lubrication Chart in Section 1.

### 2.3 LUBRICATION AND INFORMATION

#### Hydraulic System

1. 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 quantity of oil in supply tube.
2. 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. Hydraulic system filters should be checked, cleaned, and/or replaced as necessary, at the specified intervals required in the Lubrication Chart in Section 1. Always examine filters for evidence of metal particles.
3. 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.
4. 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 or filters of new machines due to the wear-in of meshing components.*

#### Hydraulic Oil

1. Refer to Section 1 for recommendations for viscosity ranges.
2. JLG recommends DTE11 hydraulic oil, which has an SAE viscosity of 10W-30 and a viscosity index of 152.

**NOTE:** *Start-up of hydraulic system with oil temperatures below -15°F (-26°C) is not recommended. If it is necessary to start the system in a sub-zero environment, it will be necessary to heat the oil with a low density, electrical heater to a minimum temperature of -15°F (-26°C).*

#### Changing Hydraulic Oil

1. Use of any of the recommended crankcase or hydraulic oils eliminates the need for changing the oil on a regular basis. However, filter elements must be changed annually unless operating in extreme conditions. 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.
2. 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. Always replace the filter and clean magnet any time the system oil is changed.
3. 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.

**NOTE:** *Refer to section 4 for oil checking and oil changing procedure.*

#### Lubrication Specifications

Specified lubricants, as recommended by the component manufacturers, are always the best choice, however, multi-purpose greases usually have the qualities which meet a variety of single purpose grease requirements. Should any question arise, regarding the use of greases in maintenance stock, consult your local supplier for evaluation. Refer to Section 1 for an explanation of the lubricant key designations appearing in the Lubrication Chart.



## 2.4 CYLINDER DRIFT TEST

Maximum acceptable cylinder drift is to be measured using the following methods.

### Platform Drift

Measure the drift of the platform to the ground. Fully elevate the platform. Maximum allowable drift is 2 inches (5 cm) in 10 minutes. If the machine does not pass this test, proceed with the following.

### Cylinder Drift

**Table 2-2. Cylinder Drift**

Cylinder Bore Diameter		Max. Acceptable Drift in 10 Minutes	
inches	mm	inches	mm
3	76.2	0.026	0.66
3.5	89	0.019	0.48
4	101.6	0.015	0.38
5	127	0.009	0.22
6	152.4	0.006	0.15
7	177.8	0.005	0.13

Drift is to be measured at the cylinder rod with a calibrated dial indicator. The cylinder oil must be at ambient temperature and temperature stabilized.

The cylinder must have the normal load, which is the normal platform load applied.

If the cylinder passes this test, it is acceptable.

**NOTE:** This information is based on 6 drops per minute cylinder leakage.

## 2.5 PINS AND COMPOSITE BEARING REPAIR GUIDELINES

Filament wound bearings.

1. Pinned joints should be disassembled and inspected if the following occurs:
  - a. Excessive sloppiness in joints.
  - b. Noise originating from the joint during operation.
2. Filament wound bearings should be replaced if any of the following is observed:
  - a. Frayed or separated fibers on the liner surface.
  - b. Cracked or damaged liner backing.
  - c. Bearings that have moved or spun in their housing.
  - d. Debris embedded in liner surface.
3. Pins should be replaced if any of the following is observed (pin should be properly cleaned prior to inspection):
  - a. Detectable wear in the bearing area.
  - b. Flaking, peeling, scoring, or scratches on the pin surface.
  - c. Rusting of the pin in the bearing area.
4. Re-assembly of pinned joints using filament wound bearings.
  - a. Housing should be blown out to remove all dirt and debris...bearings and bearing housings must be free of all contamination.
  - b. Bearing/pins should be cleaned with a solvent to remove all grease and oil...filament wound bearings are dry joints and should not be lubricated.
  - c. Pins should be inspected to ensure it is free of burrs, nicks, and scratches which would damage the bearing during installation and operation.

### 2.6 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 five 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.

#### NOTICE

**JLG INDUSTRIES REQUIRES THAT A COMPLETE ANNUAL INSPECTION BE PERFORMED IN ACCORDANCE WITH THE "ANNUAL MACHINE INSPECTION REPORT" FORM.**

**NOTE:** *This machine requires periodic safety and maintenance inspections by a JLG Dealer. Notify dealer if inspection is overdue.*

The inspection and maintenance code numbers are as follows:

1. Check for proper and secure installation.
2. Check for visible damage and legibility.
3. Check for proper fluid level.
4. Check for any structural damage; cracked or broken welds; bent or warped surfaces.
5. Check for leakage.
6. Check for presence of excessive dirt or foreign material.
7. Check for proper operation and freedom of movement.
8. Check for excessive wear or damage.
9. Check for proper tightness and adjustment.
10. Drain, clean and refill.
11. Check for proper operation while pump/motor is running.
12. Check for proper lubrication.
13. Check for evidence of scratches, nicks or rust and for straightness of rod.
14. Check for condition of element; replace as necessary.
15. Check for proper inflation.

Table 2-3. Preventive Maintenance and Safety Inspection

AREA	INTERVAL				
	Daily	Weekly	100 Hours (3 Months)	200 Hours (6 Months)	400 Hours (1 year)
<b>PLATFORM</b>					
Controller	1,11				
Switches	1,11				
Placards and Decals	1,2				
Control Tags	1,2				
Hoses and Cables		4,8			
Wear Pads				8,12	
Handrails and Chains	1,4				
<b>CHASSIS</b>					
Battery	3	5			
Hydraulic Pump	1	5			
Valves	1	5			
Hydraulic Filter	ANNUAL				
Hydraulic Hoses and Tubing	1	5			
Hydraulic Oil Tank		5		3,4	
Lift Cylinder	1,12	5,6,13		4	
Limit Switch	1,7				
Tilt Alarm Switch					1,7
Placards and Decals	1,2				
Wheel and Tire Assemblies	1	8,9			
Drive Motors		1,5,6			
Drive Brakes		1,6		8	
Drive Torque Hubs		1,3,5,6			
Steer Cylinder	1	5,6,13		4	
Steer Components	1	4,6		8	
Wheel Bearings				8	12
Scissor Arms	1,4				
Safety Props	1,4				
Sliding Wear Pads				8,12	
Pivot Pins/Bolts	1,4			7,8	
Switches, Ground Control	1,11				
Control Tags	1,2				

**SECTION 2 - GENERAL**

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**NOTES:**

Lined area for notes, consisting of two columns of horizontal lines.

## SECTION 3. CHASSIS & SCISSOR ARMS

### 3.1 DIAGNOSTIC PORT

The diagnostic port is located behind the battery cover at the near the ground control station as shown below. The MDI (Multifunction Digital Indicator) and the JLG Hand-Held Analyzer can be connected at this port..



Figure 3-1. Diagnostic Port

### 3.2 MDI (MULTIFUNCTION DIGITAL INDICATOR) AND BRAKE RELEASE



MDI and Brake Release Bracket

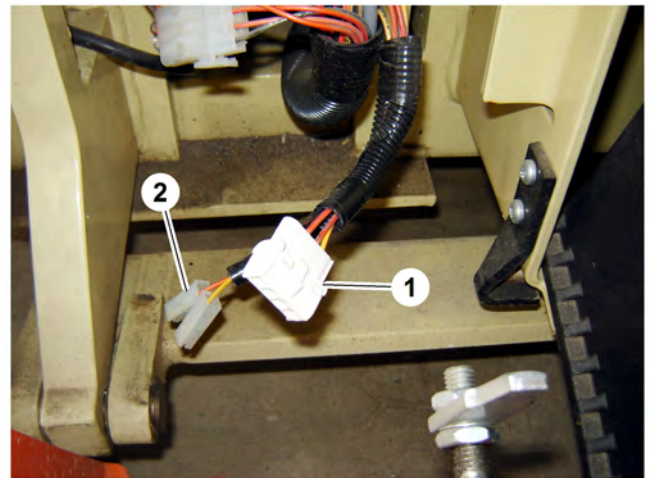
#### Installation:

**NOTE:** In order for the MDI to be functional the machine must be equipped with either the Sevcon Power Module with Ground Module Software Version P1.13 or higher, or the ZAPI Power Module. Use the JLG Hand-held Analyzer to check the Sevcon software version. Plug analyzer into diagnostic port. Scroll to DIAGNOSTICS -> VERSIONS. Must be at least GM. SW P1.13. Refer to Section 5.6, Updating Software, for instructions on updating software.

#### NOTICE

**ENSURE EMS BUTTONS ON THE CONTROL STATIONS ARE PUSHED IN TO THE OFF POSITION BEFORE CONNECTING AND MOUNTING THE MDI AND BRAKE RELEASE BRACKET.**

1. Open the Battery Cover on the right side of the machine (ground control station side). Lifting up on the battery tray and pulling out will allow for maximum extension.
2. Locate the Diagnostic Port (1) and Brake Release Plugs (2).



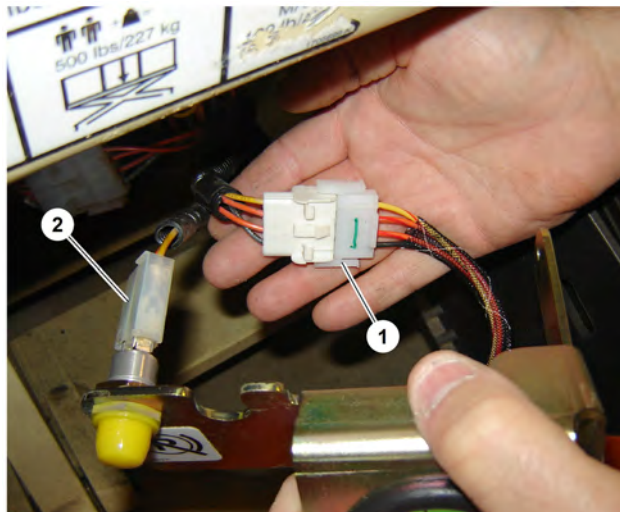
1. Diagnostic Port
2. Brake Release Plugs

3. Apply di-electric grease to the two Brake Release Plugs. Connect the Brake Release Plugs to the Brake Release Button on the backside of the mounting bracket.

**NOTE:** The brake release plugs have no polarity, therefore, can be connected to either post on the button.

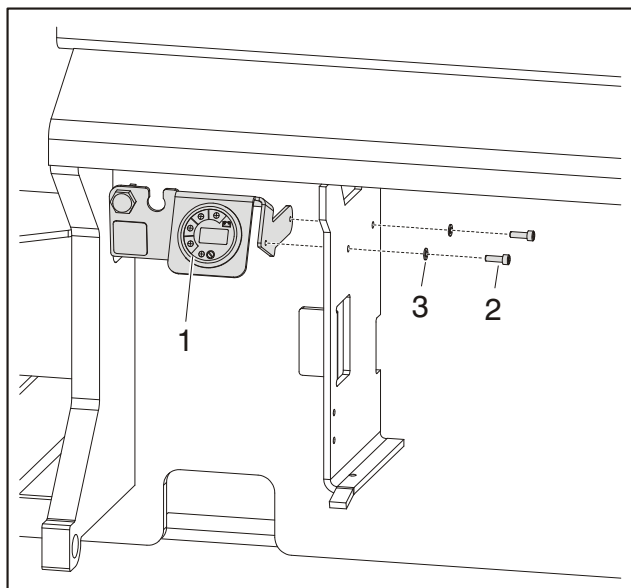
## SECTION 3 - CHASSIS & SCISSOR ARMS

4. Connect the MDI harness to the Diagnostic Port.



1. MDI Connected
2. Brake Release Connected

5. Using a 5/32" allen wrench, mount the MDI and Brake Release Bracket onto the wall of the battery compartment. (appropriate mounting holes are pre-existing) Apply Loctite #242 to the screws and torque to 3.6 ft-lb (5 Nm). (Refer to Figure 3-2.)



1. MDI & Brake Release Bracket
2. Screw, M5 x 16
3. Washer, 5mm

**Figure 3-2. MDI Installation/Removal**

5. Power machine and check to ensure LEDs on MDI work. Check to ensure Brake Release Button works. If the Software Version is not P1.13 or higher, "Error" will display on the LCD. If a fault exists, the trouble code will display on the LCD. (Refer to Section 6, Diagnostic Trouble Codes)
6. Using zip ties, tie back cables and wires to prevent damage to the cables and wires.



**Removal:**

### **NOTICE**

**ENSURE EMS BUTTONS ON THE CONTROL STATIONS ARE PUSHED IN TO THE OFF POSITION BEFORE DISCONNECTING THE MDI AND BRAKE RELEASE BRACKET.**

1. Remove the two Screws (2) and Washers (3).
2. Disconnect Brake Release and MDI from the electrical harnesses.
3. Remove Bracket.

### 3.3 TRACTION SYSTEM

#### Theory of Operation

The Armatures (rotating windings) of the separately-excited drive motors are wired in parallel to the Power Module's M1 and M2 terminals (Sevcon) and -T and +B terminals (ZAPI) . The M1/+B Terminal is always at the same voltage as the +B (Battery Voltage when the Line Contactor is closed) and allows the module to measure current with the internal shunt (extremely low impedance). The M2/-T Terminal is pulled to Ground by the Armature Switch MOSFET's (connected to -B Terminal).

To provide variable speed control, the Armature MOSFET transistors switch On and Off at high frequencies (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 Battery Voltage will be applied to the Armatures. Similarly, the MOSFET are On continuously (100% Duty Cycle) to apply all available Battery Voltage to the Armatures (as in Driving at Full Speed).

Instead of permanent magnets, the separately-excited drive motors use electro-magnets (called Field Windings) located in the stator (non-rotating) portion of the motor. Field windings are preferable to permanent magnets because the Power Module can adjust the stator's magnetism for optimum motor performance. When climbing a grade at low speeds, the Power Module may apply as much as 40A to the field windings for more electro-motive force. On level terrain, the Power Module will apply as little as 14A to the fields for higher rotational speeds and better electrical efficiency.

The Field Windings also provide direction reversal for traction. When driving forward, MOSFET switches 1 and 4 turn On to apply positive potential to F2 and ground potential to F1. In reverse, MOSFET switches 2 and 3 turn On to apply positive potential to F1 and ground potential to F2. These switches are pulse-width modulated by the Power Module to maintain a fixed relationship between Field and Armature Current (also called the Field Map).

Since the two 24V Armatures are wired in parallel, the drive motors will attempt to rotate at the same speed under all conditions. If one wheel slips, the wheel with traction will demand more current as it slows slightly (under load). In this manner, the system provides effective traction control with no added complexity.

It is essential that the same amount of field current is supplied to both drive motors, or one wheel will pull the vehicle (motor overheating and excessive tire wear would result). Independent field control would require a more complex Power Module, and parallel field windings would require impedance matching. For simplicity, the vehicle uses 12V field windings wired in series to ensure proper distribution of current.

Two electrically-released parking brakes are mounted to the rear of the drive motors. The Ground Module energizes the two 24V electro-magnets when appropriate to allow vehicle motion. The parking brakes can be released electrically for emergency vehicle towing.

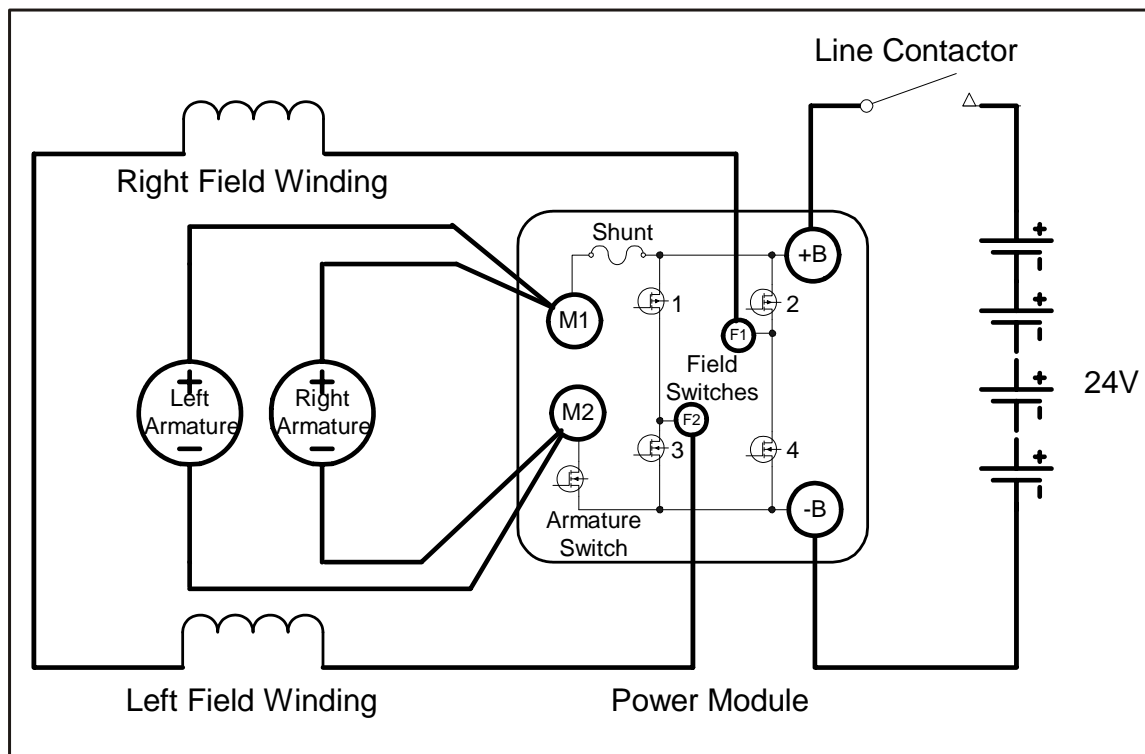


Figure 3-3. Traction Control Circuit - Sevcon Power Module

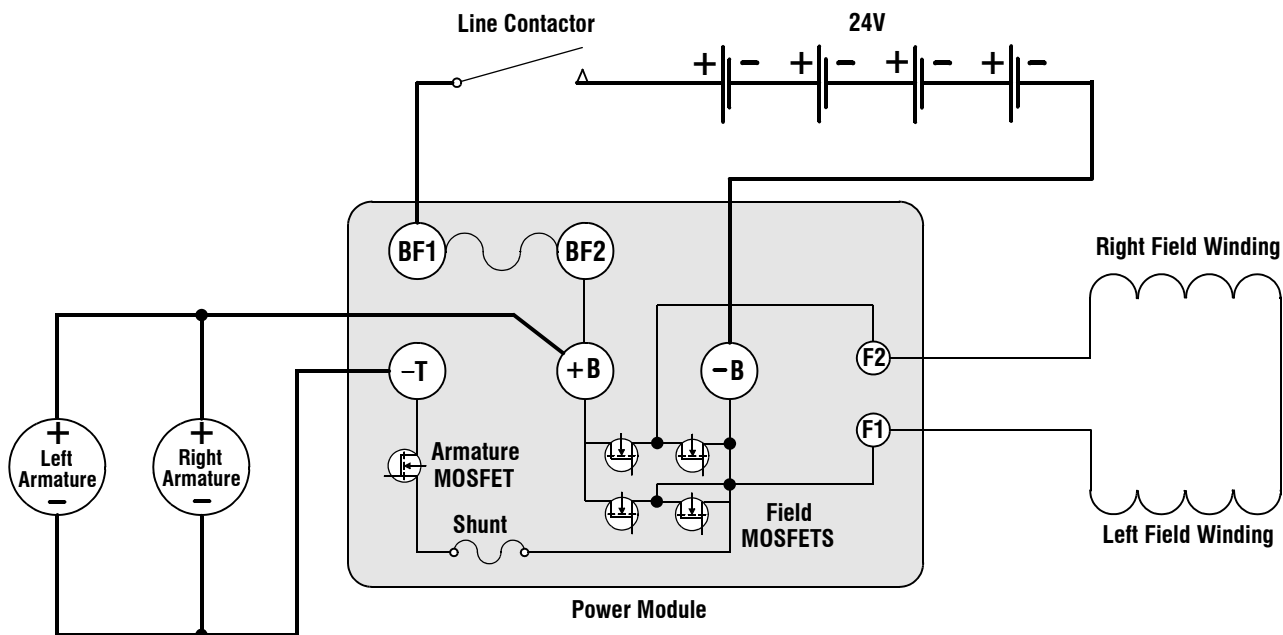


Figure 3-4. Traction Control Circuit - ZAPI Power Module



### 3.4 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.**

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. 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

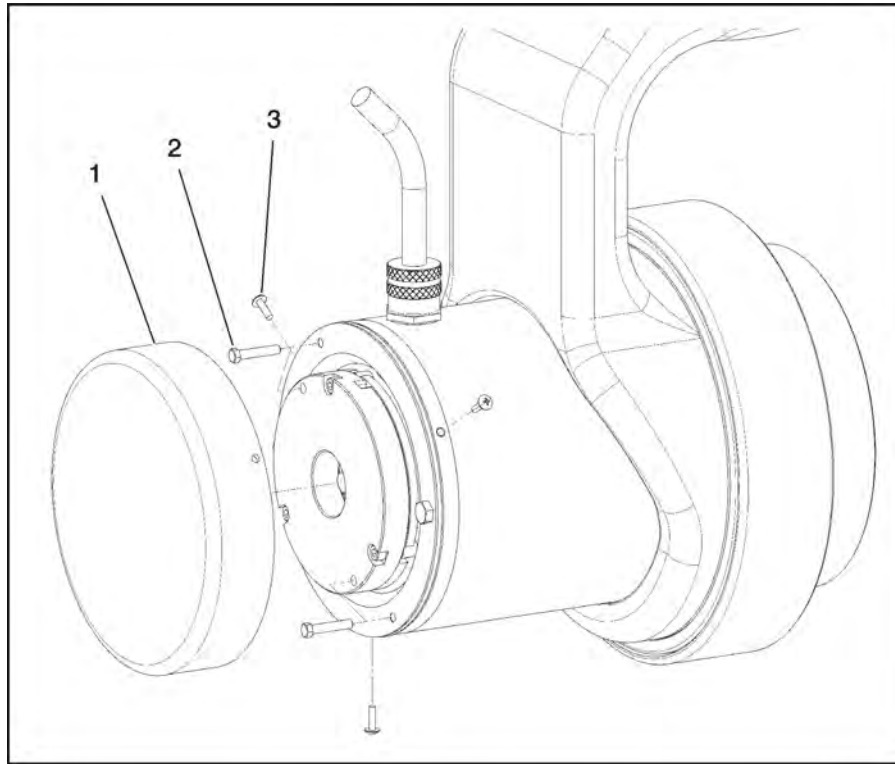
The torque hub unit is shipped with ISO 68 viscosity oil (hydraulic fluid). It is designed to utilize the same oil throughout its service life. However, should it need to be checked/serviced use the following procedure.

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

**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 then 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).

## Manual Disengage Procedure



- |                    |                      |
|--------------------|----------------------|
| 1. Brake Cover     | 3. Brake Cover Bolts |
| 2. Disengage Bolts |                      |

**Figure 3-5. Disengage Procedure**

**NOTE:** Applies only to:  
USA machines built prior to S/N 0200118041,  
Belgium machines built prior to S/N 1200001487.

In the event of a power loss to the Torque-Hub, the parking brake will engage as a safety precaution. Should the unit need to be towed or pushed to an area where it can be serviced or recharged the operator will need to manually disengage the parking brakes. The following procedure outlines how this is to be done.

### **⚠ 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.**

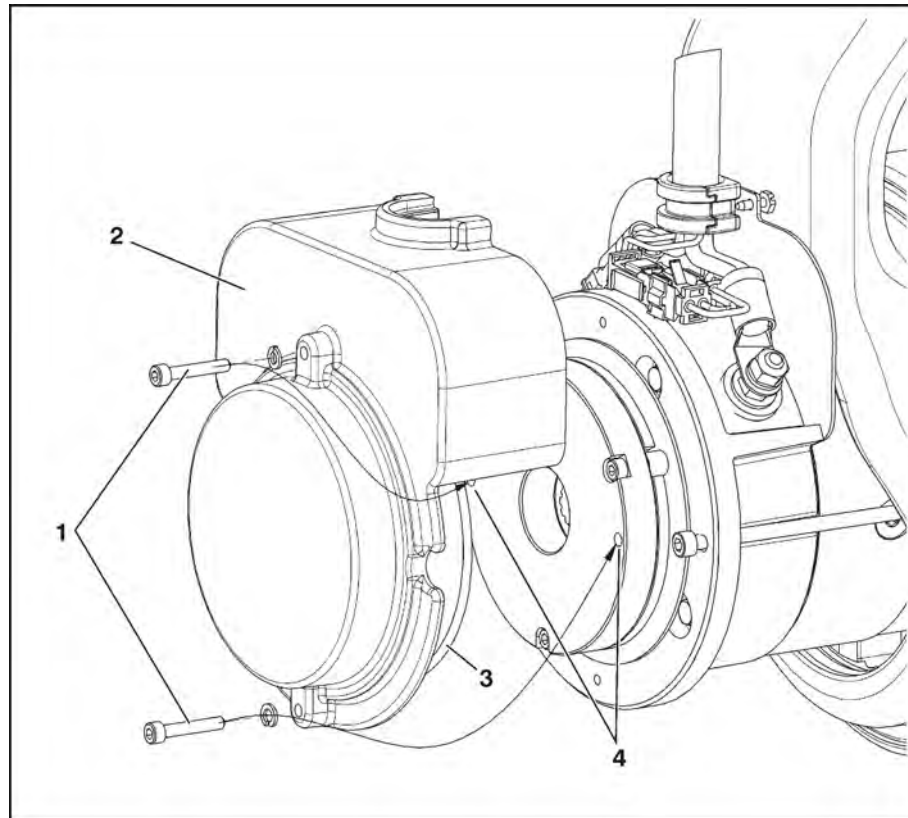
1. Remove the 3 brake cover bolts from the back end of the motor.
2. Remove brake cover.

3. Locate the 2 disengage bolts that are stored in the motor end-cap.
4. Remove these bolts and insert them into the two holes in the brake housing.
5. Tighten down bolts and the brake will disengage.
6. Repeat this procedure for the other wheel drive.

### **⚠ CAUTION**

**THE DISENGAGE BOLTS MUST BE REMOVED FROM THE BRAKE HOUSING AFTER THE MACHINE IS TOWED OR PUSHED TO ITS SERVICING LOCATION. THE BRAKES CAN NOT BE ENGAGED WITH THE DISENGAGE BOLTS IN THE BRAKE HOUSING. THIS WILL CAUSE THE MACHINE TO ROLL WHEN PARKED ON AN INCLINE.**

## Manual Disengage Procedure



- |                      |                      |
|----------------------|----------------------|
| 1. Brake Cover Bolts | 3. Cover O-ring Seal |
| 2. Brake Cover       | 4. Disengage Holes   |

**Figure 3-6. Disengage Procedure**

**NOTE:** Applies only to:  
 USA machines built S/N 0200152825 to S/N 020170585,  
 Belgium machines built S/N 1200008481 to S/N 1200015159.

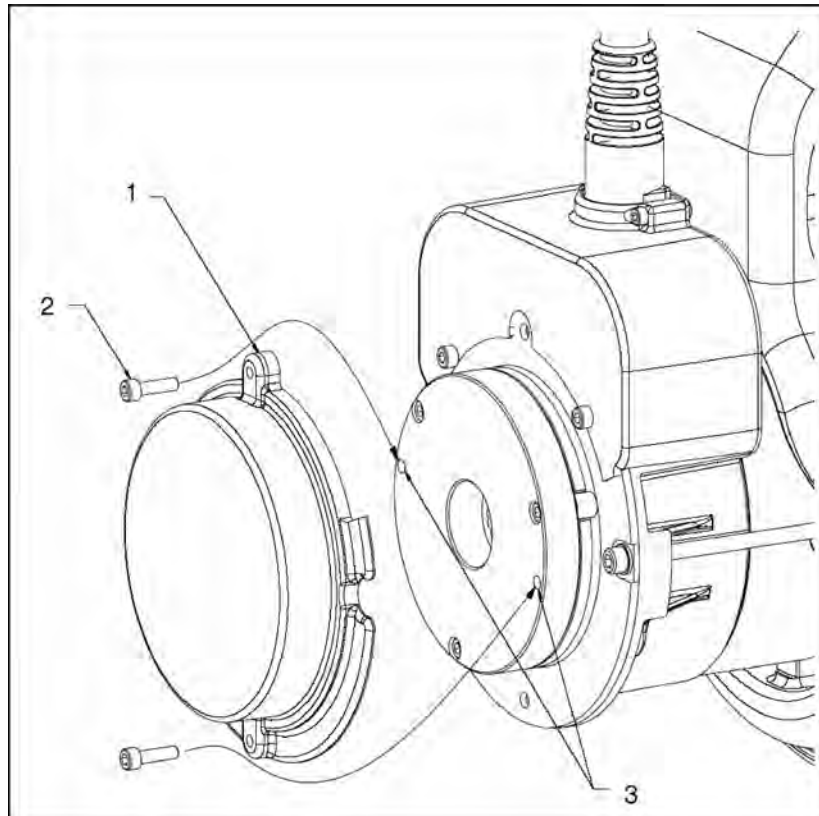
1. Chock wheels or secure machine with tow vehicle.
2. Power machine in ground mode.
3. Remove the two cover bolts, cover, and cover o-ring seal from the back of drive motor unit.
4. Insert the cover bolts into the two disengage holes in the brake housing.
5. Tighten down the bolts and the brake on that drive motor will disengage.
6. Repeat this procedure on opposite wheel drive. With both drive motor brakes now disengaged, the machine can be moved manually.
7. After towing is complete, chock wheels and remove cover bolts from disengage holes.

8. Reinstall cover. Before installation, check the cover o-ring seal for damage, replace if necessary.

### **CAUTION**

**AFTER THE MACHINE IS TOWED, THE DISENGAGE BOLTS MUST BE REMOVED FROM THE BRAKE DISENGAGE HOLES. THE BRAKES CANNOT BE ENGAGED WITH THE DISENGAGE BOLTS IN THE BRAKE DISENGAGE HOLES. THIS WILL CAUSE THE MACHINE TO ROLL WHEN PARKED ON AN INCLINE.**

## Manual Disengage Procedure



- 1. Brake Cover
- 2. Cover Bolts
- 3. Disengage Holes

**Figure 3-7. Disengage Procedure**

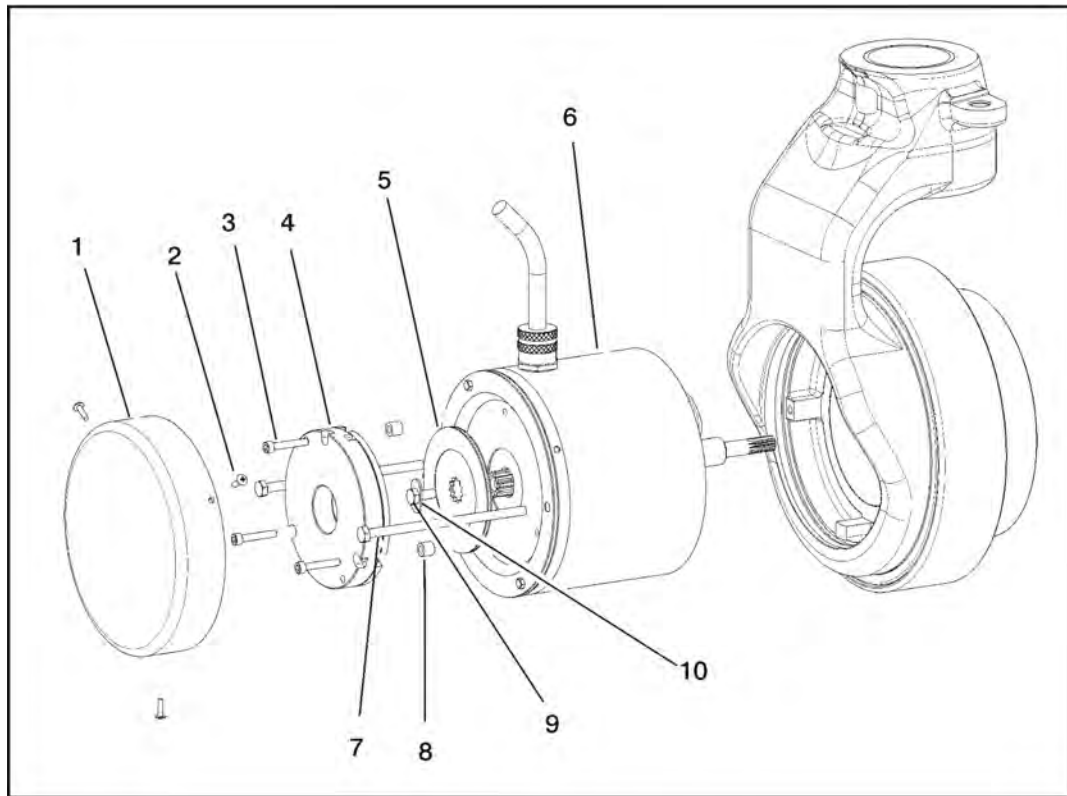
**NOTE:** Applies only to:  
USA machines built S/N 0200170585 to Present,  
Belgium machines built S/N 1200015159 to Present.

1. Chock wheels or secure machine with tow vehicle.
2. Ensure battery disconnect switch is in to the "OFF" position.
3. Remove the two Cover Bolts and Brake Cover.
4. Insert the Cover Bolts into the two Disengage Holes in the brake housing.
5. Tighten down the Cover Bolts and the brake on that drive motor will disengage.
6. Repeat this procedure on opposite wheel drive. With both drive motor brakes now disengaged, the machine can be moved manually.
7. After towing is complete, chock wheels and remove Cover Bolts from Disengage Holes.
8. Reinstall Brake Cover.

**⚠ CAUTION**

**AFTER THE MACHINE IS TOWED, THE DISENGAGE BOLTS MUST BE REMOVED FROM THE BRAKE DISENGAGE HOLES. THE BRAKES CANNOT BE ENGAGED WITH THE DISENGAGE BOLTS IN THE BRAKE DISENGAGE HOLES. THIS WILL CAUSE THE MACHINE TO ROLL WHEN PARKED ON AN INCLINE.**

## Motor and Brake Disassembly



- |                       |                  |                   |
|-----------------------|------------------|-------------------|
| 1. Brake Cover        | 5. 5. Disc Brake | 9. Retention Bolt |
| 2. Disengage Bolts    | 6. Motor         | 10. Washer        |
| 3. Socket Head Screws | 7. Thru Bolts    |                   |
| 4. Brake Housing      | 8. Spacers       |                   |

**Figure 3-8. Motor & Brake Disassembly**

**NOTE:** Applies only to:

USA machines built prior to S/N 0200118041,  
Belgium machines built prior to S/N 1200001487.

1. Drain the oil out of the unit by removing pipe plug. Note the condition of the oil.
2. Perform the manual disengage procedure outlined in a previous page.
3. Disconnect the brake connector (not shown).
4. Remove the 3 socket head screws in the brake housing.

**NOTE:** Each screw goes through a spacer when assembled. When the screw is removed the spacer will become loose.

5. Remove the three spacers and the brake housing.

6. Remove the retention bolt and washer from the end of the motor shaft.
7. Remove the brake disc from the motor shaft.

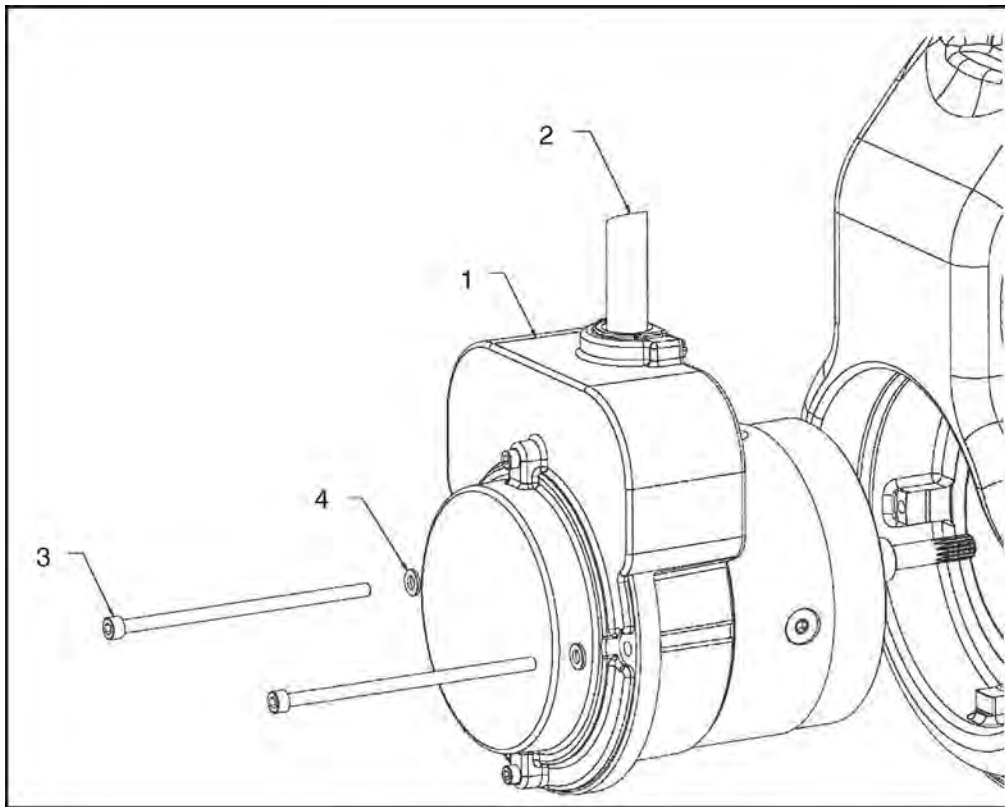
**NOTICE**

**REINSTALL THE RETENTION BOLT AND WASHER INTO THE END OF THE MOTOR SHAFT.**

8. Remove the two thru bolts that bolt through the motor housing.
9. Gently remove the motor.

**NOTE:** Care should be taken when removing the motor. A good method is to use a pry bar between the strain relief of the cable and the back of the spindle. While applying gentle pressure to the pry bar, tap the bottom of the motor housing with a rubber mallet. The motor should slip out.

## Motor Disassembly



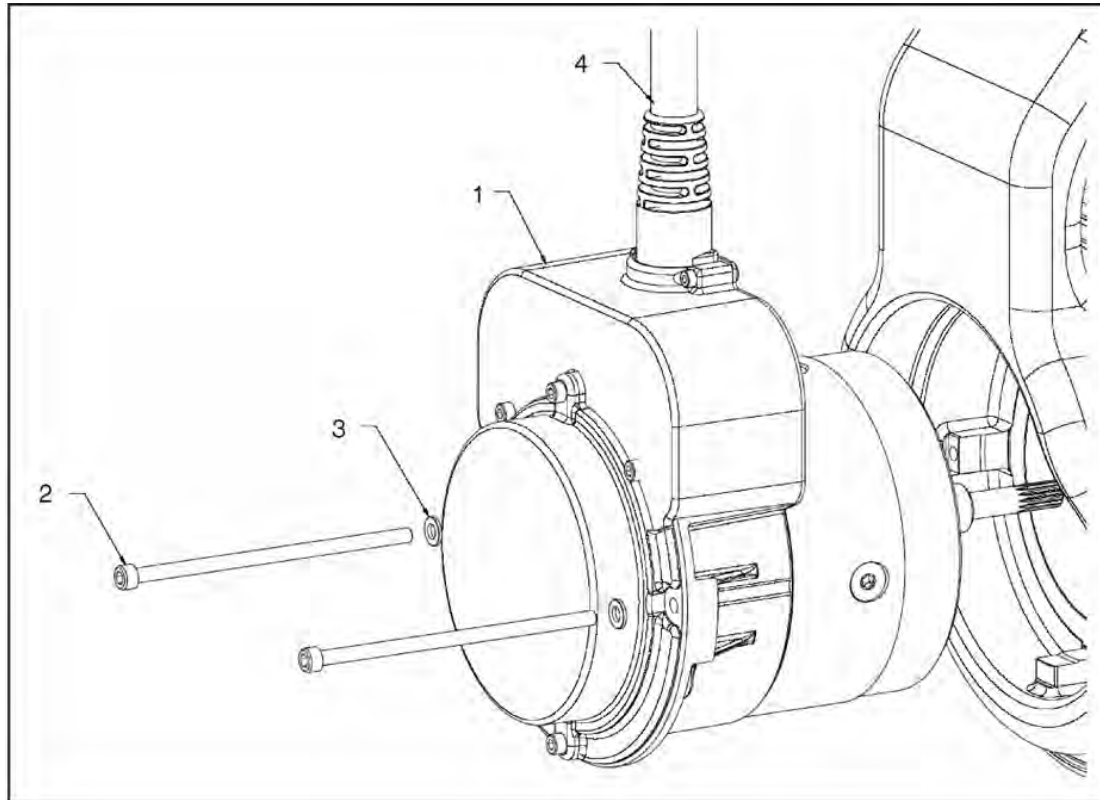
- |          |           |
|----------|-----------|
| 1. Motor | 3. Bolt   |
| 2. Cable | 4. Washer |

**Figure 3-9. Motor Disassembly**

**NOTE:** Applies only to:  
USA machines built S/N 0200152825 to S/N 020170585,  
Belgium machines built S/N 1200008481 to S/N 1200015159.

1. Make sure the E-stop button is pushed in.
2. Disconnect the cable from the power control module.
3. Drain the oil out of the unit by removing the pipe plug, note the condition of the oil.
4. Remove the 2 motor mounting bolts and washers.
5. Gently remove the motor.

## Drive Motor Removal



- |                         |                |
|-------------------------|----------------|
| 1. Drive Motor          | 3. Washers     |
| 2. Motor Mounting Bolts | 4. Motor Cable |

**Figure 3-10. Motor Removal**

**NOTE:** Applies only to:  
 USA machines built S/N 0200170585 to Present,  
 Belgium machines built S/N 1200015159 to Present.

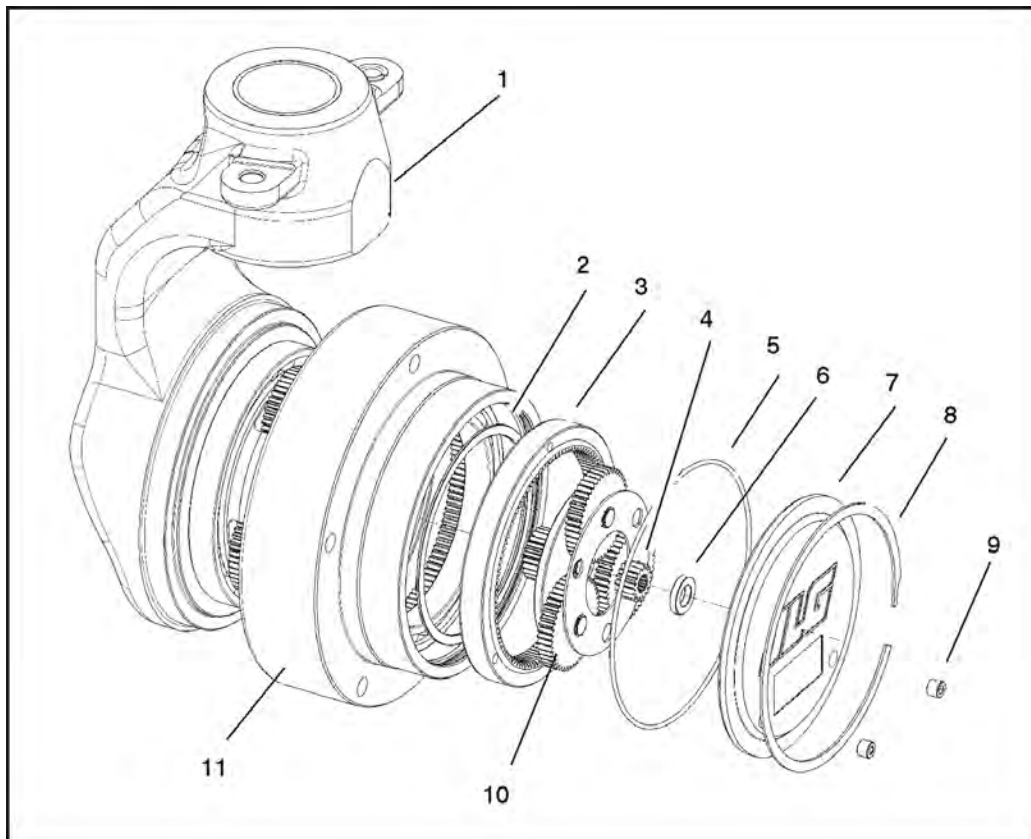
3. Remove the two motor mounting bolts and washers.
4. Gently remove the drive motor (1).

**⚠ CAUTION**

**ENSURE THE BATTERY DISCONNECT SWITCH IS IN THE OFF POSITION BEFORE REMOVING DRIVE MOTOR.**

1. Disconnect the motor cable from the power control module.
2. Drain the oil out of the unit by removing the cover plug. Note the condition of the oil, replace if necessary.

## Main Gearbox Disassembly



- |                         |                        |                                |
|-------------------------|------------------------|--------------------------------|
| 1. Spindle Sub-Assembly | 5. Cover O-Ring        | 9. Pipe Plug                   |
| 2. Spiral Snap Ring     | 6. Cover Thrust Washer | 10. Input Carrier Sub-Assembly |
| 3. Input ring Gear      | 7. Cover               | 11. Hub Sub-Assembly           |
| 4. Input Sun Gear       | 8. Cover Snap Ring     |                                |

**Figure 3-11. Main Gearbox Disassembly**

1. Using a screwdriver, pry off the cover snap ring.
2. Remove cover. Cover Thrust washer should be in the inner counter bore of the cover.

**NOTE:** To grip the cover for removal a pipe may need to be inserted into the pipe plug holes.

3. Remove input sun gear.
4. Remove input carrier sub-assembly.
5. Remove cover o-ring.
6. Remove input ring gear.

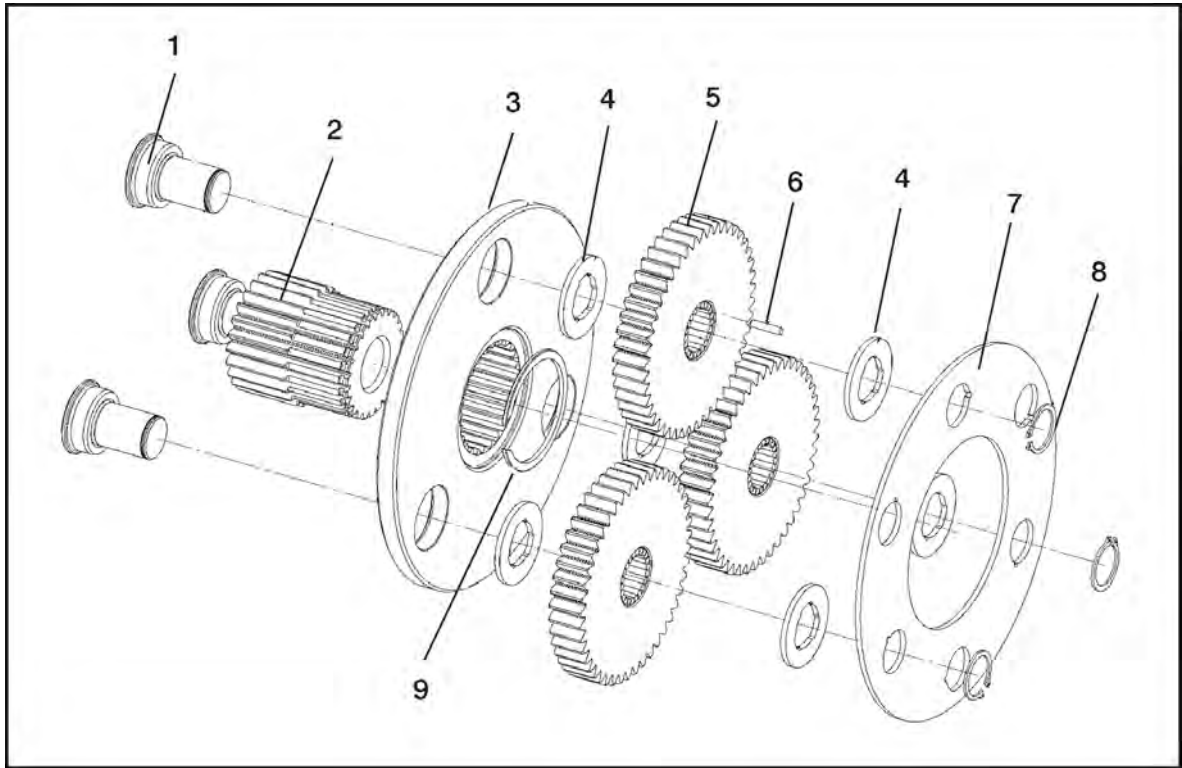
**NOTE:** The input ring gear is held in with a press fit on its outside diameter. Insert jacking screws (1/4-20UNC grade 8) with at least 1.5 inches of thread length into

each of the three tapped holes to force the ring gear out. Be sure and alternate between the jacking screws to keep the ring gear from becoming misaligned in the bore. The screws will push against the outer race of the main bearing. This bearing will have to be replaced afterwards.

7. Using a screwdriver remove spiral snap ring.
8. Pull hub sub-assembly off of the spindle sub-assembly.



## Input Carrier Disassembly



- |                     |                      |                   |
|---------------------|----------------------|-------------------|
| 1. Planet Gears     | 4. Thrust washer     | 7. Thrust Plate   |
| 2. Output Sun Gears | 5. Input Planet Gear | 8. Snap Ring      |
| 3. Input Carrier    | 6. Needle Bearings   | 9. Retaining Ring |

**Figure 3-12. Input Carrier Disassembly**

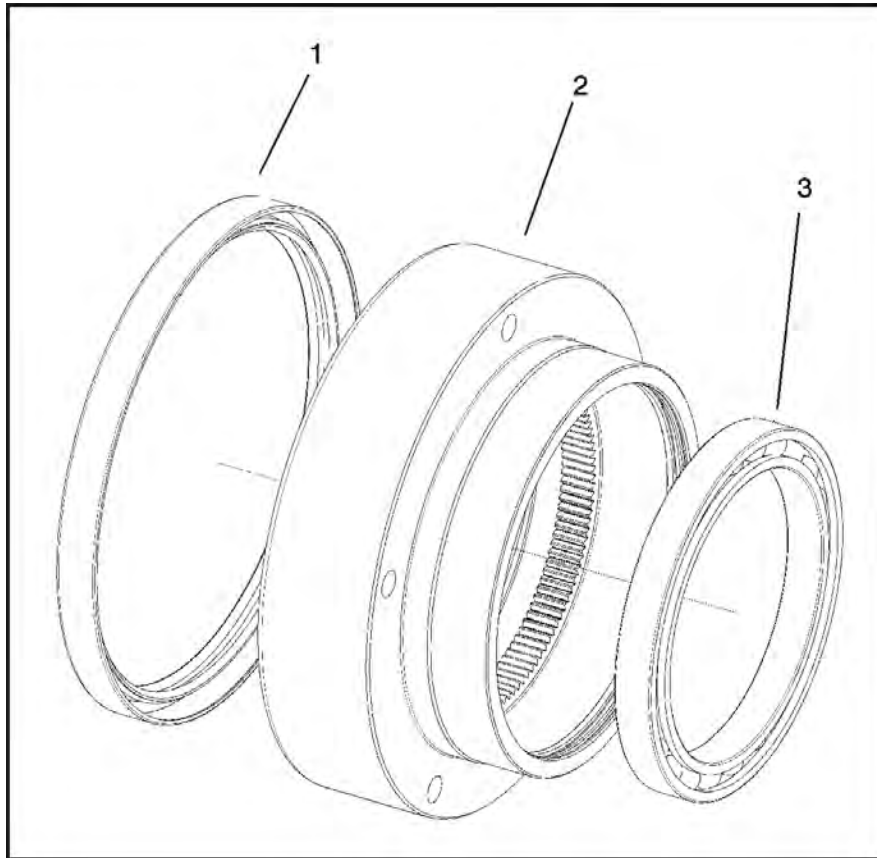
1. Remove retaining rings from each of the 3 planet shafts.

**NOTE:** Do not overstress these retaining rings when removing them.

2. Remove thrust plate.
3. Remove a thrust washer from each planet shaft.
4. Slide each input planet gear off the planet shaft.
5. Remove 22 needle bearings from the bore of each planet gear.
6. Remove the thrust washer from each planet gear.
7. Remove retaining ring from output sun gear.
8. Slide output sun gear out from the center of the input carrier.
9. Remove the three planet shafts from the input carrier.

**NOTE:** The planet pins are held in with a press fit. To avoid damage to the parts, use an arbor or hydraulic press to remove the planet pins.

## Hub Disassembly



1. Seal
2. Hub
3. Main Bearing

**Figure 3-13. Hub Disassembly**

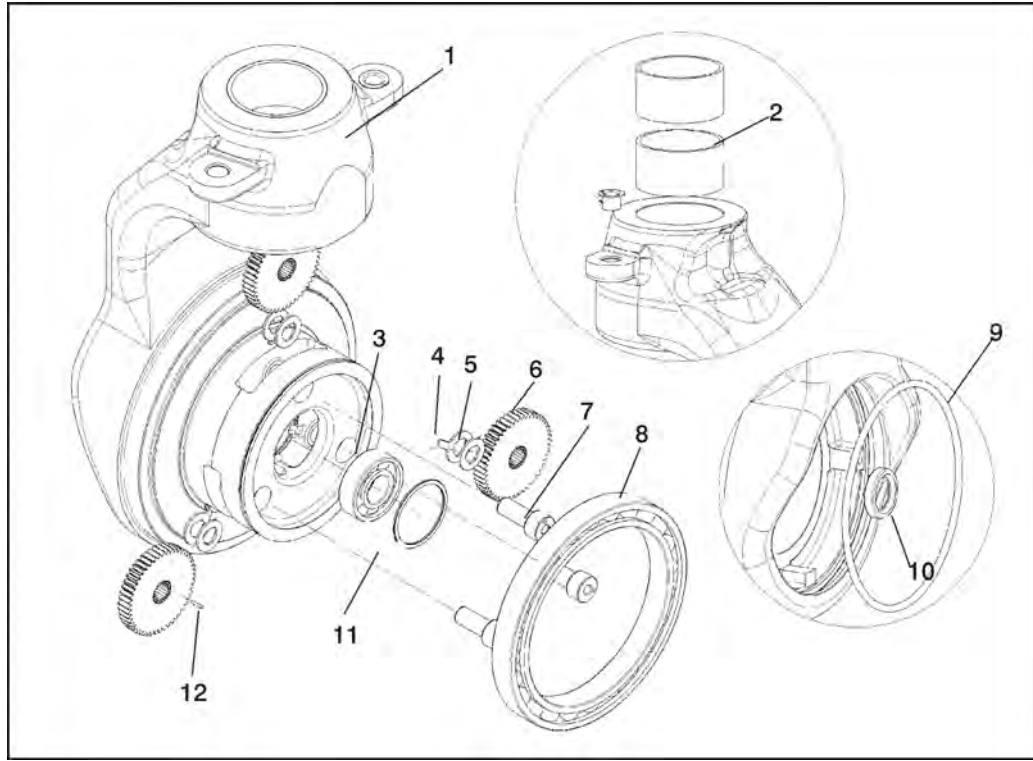
1. Remove main wheel bearing.

**NOTE:** This part is held in the hub with a press. To remove have the hub sitting seal side up. Use a plate or rod with a large enough diameter push in the inner race of the bearing. Apply force to the push the bearing out. This bearing will need to be replaced upon reassembly.

2. Remove main lip seal.

**NOTE:** This lip seal is also held in with a press fit. Remove the lip seal only if the hub or seal needs to be replaced. The lip seal will most likely become damaged during removal. Try not to damage the hub bore.

## Spindle Disassembly



- |                         |                       |                            |
|-------------------------|-----------------------|----------------------------|
| 1. Spindle Sub-Assembly | 5. Thrust Washer      | 9. O-Ring                  |
| 2. Main Bushing         | 6. Output Planet Gear | 10. Shaft Seal             |
| 3. Shaft Ball Bearing   | 7. Output Planet Pins | 11. Snap Ring              |
| 4. Tanged Washer        | 8. Main Bearing       | 12. Needle Roller Bearings |

**Figure 3-14. Spindle Disassembly**

1. Place unit on bench with planet gears facing up.
2. Remove 3 output planet shafts.
 

**NOTE:** These planet shafts are held in with a press fit. Use the tapped hole in the end of the pin in conjunction with a slide hammer or similar tool to remove them.
3. Remove the output planet gear, thrust washer, and tapered washer out of each gear "window" of the spindle.
 

**NOTE:** The output planet gears are a very similar size to the input planet gears, tag or label the planet gears to avoid confusion.
4. Using a screwdriver remove the shaft bearing snap ring.
5. Remove the shaft ball bearing from the center bore.
6. Press out the motor shaft seal from the center bore.
7. Remove the main bearing from the outside diameter of the spindle.
 

**NOTE:** This bearing is held in with a press fit. You will need to pry against the spindle to remove it. The bearing will need to be replaced when this is done.
8. Press out the main bushings at the top of the spindle neck.
9. Remove the motor O-ring from the groove on side opposite from the carrier side.

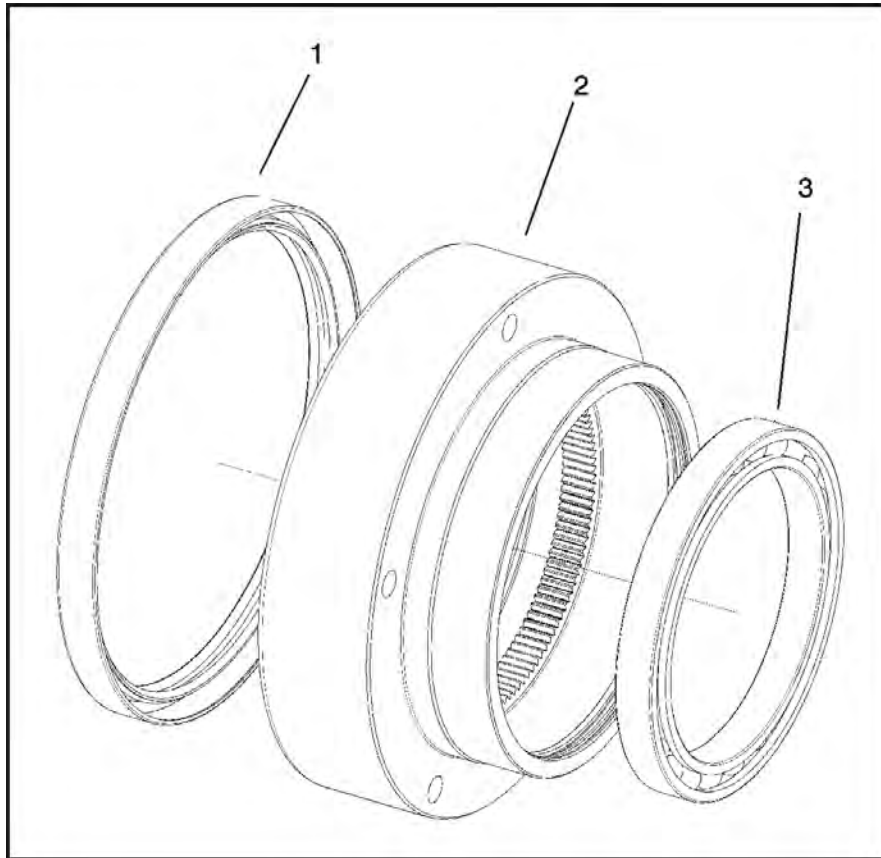
### Spindle Sub-Assembly

1. Using an appropriate pressing tool, press in the 2 main bushings in the upper bore of the spindle. The lower bushing needs to be flush with the bottom of the bore and the upper bushing needs to be flush with the bottom of the bore.
2. Using the clevis pin from the steering linkage or an M12 bolt, drive the flanged steer link bushing into the appropriate spindle ear hole. If the wheel drive is for the left wheel then, with the carrier side up and kingpin bore oriented to the top, put the steer link bushing in the left ear.
3. Using the appropriate pressing tool, press on main bearing until it is fully seated.
4. Insert the motor shaft bearing into the center bore of the spindle. The bearing is a slight slip fit, but it may require some press to assemble if the bearing becomes misaligned.
5. Retain the bearing with the spiral retaining ring.
6. Line the bore of the output planet gear with 22 needle rollers. Use grease to retain the needle rollers in the bore.
7. Place tanged thrust washer into each planet “window” of the spindle. Make sure the tang sits in the cast groove on the inside of the window.
8. Place a thrust washer onto the plane gear. Line up the bores as best as you can. Use grease to hold the thrust washer in place.
9. Slide the planet gear into the window with the tanged washer until the bores line up.
10. Insert an output planet pin into the planet pin hole of the spindle and through the bores of the thrust washers and the planet gear.
11. Before pressing the planet pin into the spindle make sure the gear spins freely.
12. Press the planet pin into the spindle until it bottoms out. Make sure the planet gear turns freely after the planet pin is pressed in.
13. Repeat Steps 6-12 for the other two output planet gears.
14. Turn the spindle over so that the carrier is down.
15. Using a flat plate or rod, press the motor shaft seal into the center bore so that it is flush with the face of the spindle.
16. Grease and install the motor O’ring into the groove.

#### **WARNING**

**CARE SHOULD BE TAKEN TO PREVENT ANY OIL FROM MAKING CONTACT WITH THE BRAKE DISCS. IF THIS OCCURS IT WILL DEGRADE THE BRAKES PERFORMANCE.**

## Hub Sub-Assembly



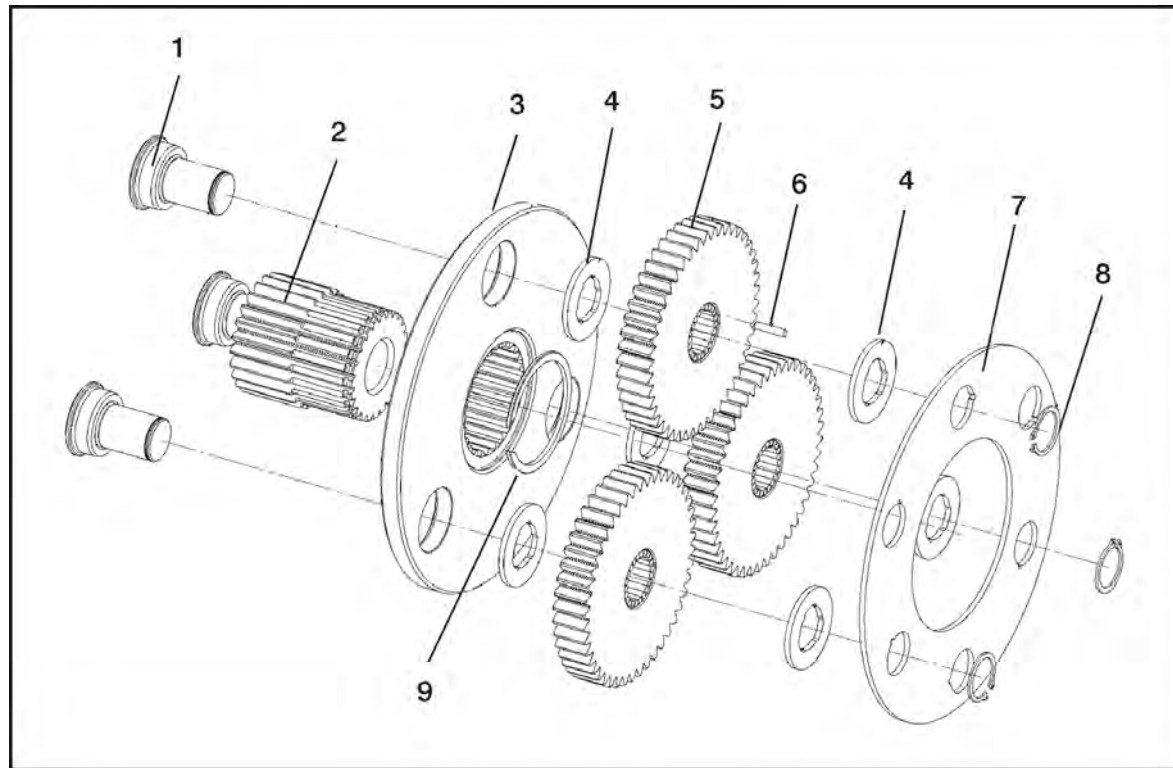
1. Seal
2. Hub
3. Main Bearing

**Figure 3-15. Hub Disassembly**

1. Put hub on a table with the tapped holes facing down.
2. Using a flat plate in conjunction with a pressing tool, press in the seal so it is flush with the edge of the hub.
3. Flip the hub over.
4. Using an appropriate pressing tool, press the main bearing into the bore until it bottoms out.

**NOTE:** *The seal has a thin outer shell that can be easily damaged if not installed with care. It is a good idea to start the seal into the bore with a rubber mallet before pressing.*

## Input Carrier Sub-Assembly



- |                     |                      |                   |
|---------------------|----------------------|-------------------|
| 1. Planet Gears     | 4. Thrust washer     | 7. Thrust Plate   |
| 2. Output Sun Gears | 5. Input Planet Gear | 8. Snap Ring      |
| 3. Input Carrier    | 6. Needle Bearings   | 9. Retaining Ring |

**Figure 3-16. Input Carrier Disassembly**

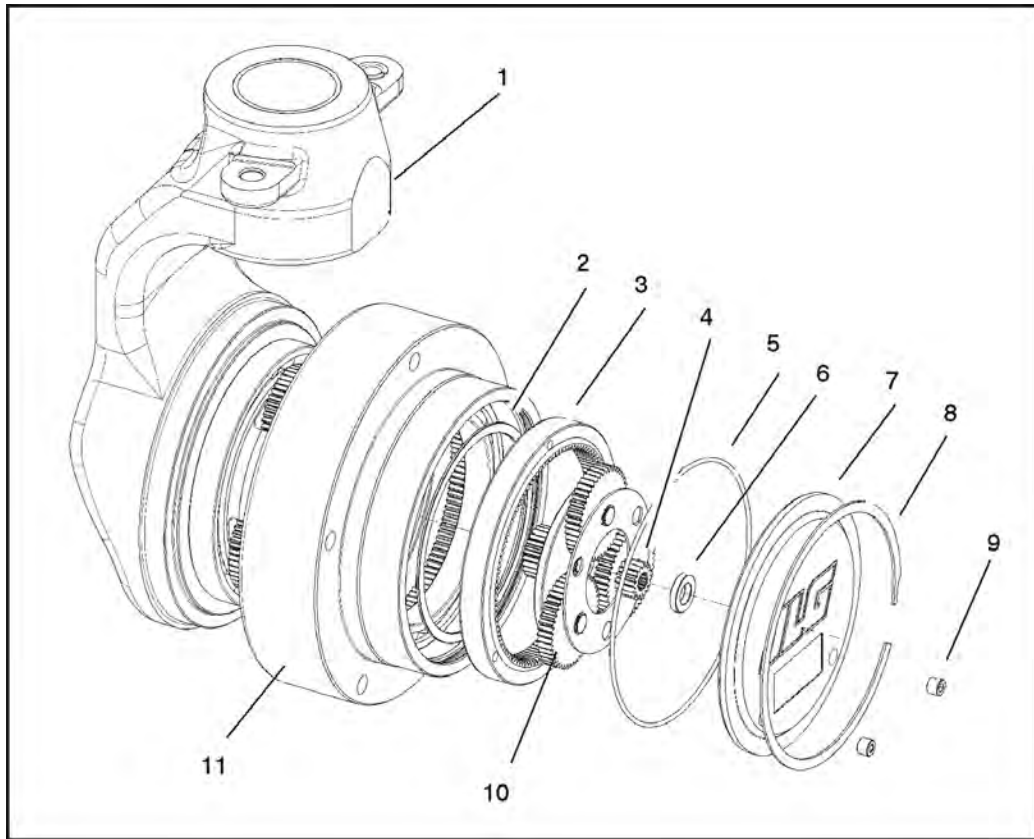
1. Press 3 input planet shafts into the 3 holes of the input carrier. The head of the input planet shaft needs to sit flush in the counter bore of the input carrier hole.
2. Insert output sun gear into the splined bore of the input carrier. The gear tooth end of the output sun gear should protrude in the opposite direction of the input planet shaft.
3. Using retaining ring pliers. Install the retaining ring into the groove of the output sun gear. Make sure that the ring is correctly seated in the groove and that the output sun gear cannot be pulled out of the input carrier.
4. Load 22 needle rollers into the bore of each input planet gear. Retain the needle bearings in the bore with a coating of grease.
5. Place a thrust washer on each side of the input planet gear. Line up the bores as well as you can

visually. Additional grease may help hold everything together.

6. Place the input planet gear and thrust washers onto the input planet shaft sticking out from the carrier. When you slide the input planet shafts into the bores, the needle bearings will try to push out. If you have the thrust washers lined up properly they will contain the needle bearings within the input planet-gear.
7. Repeat 5 & 6 for the other 2 planet gears.
8. Put the thrust plate onto the three input planet shafts. Use the 3 holes on the innermost bolt circle. The other 3 holes are for a different gear ratio.
9. Using the appropriate retaining ring pliers put a retaining ring into the groove of each planet shaft.

**NOTE:** Do not overstress the snap ring.

## Main Gearbox Assembly



- |                         |                        |                                |
|-------------------------|------------------------|--------------------------------|
| 1. Spindle Sub-Assembly | 5. Cover O-Ring        | 9. Pipe Plug                   |
| 2. Spiral Snap Ring     | 6. Cover Thrust Washer | 10. Input Carrier Sub-Assembly |
| 3. Input ring Gear      | 7. Cover               | 11. Hub Sub-Assembly           |
| 4. Input Sun Gear       | 8. Cover Snap Ring     |                                |

**Figure 3-17. Main Gearbox Disassembly**

1. Inspect seal surface of spindle. Remove any debris that may be present.
2. Apply a coating of grease to the lip seal of the hub sub-assembly.
3. Place Spindle Sub-Assembly on table with carrier side up.
4. Carefully install the hub sub-assembly (seal side down) onto the spindle. This installation should be a slip fit and takes place in 3 stages.
  - a. *Stage 1:* The hub slides together until the gear teeth of the hub hit the gear teeth of the 3 output planets.
  - b. *Stage 2:* Find the planet gear that is tight and turn it until you feel it go into mesh with the hub gear teeth, apply slight downward pressure to the hub and then find the next gear that is tight and do the same.
  - c. *Stage 3:* Once all the planet gears are in mesh apply pressure to the hub, it should go on the rest of the way.
5. Install retaining ring into the groove on the OD of the spindle carrier. This is a spiral retaining ring so it will not require pliers. You will need to pull the retaining ring apart and work it into the groove.

### SECTION 3 - CHASSIS & SCISSOR ARMS

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6. Using an appropriate pressing tool, press the Input Ring gear (**recessed side down**) into the hub sub-assembly.

**NOTE:** *Do not use excessive pressing force because it will be reacted by the main wheel bearings.*

7. Install the input carrier sub-assembly into mesh. The output sun portion of the sub-assembly will mesh with the output planet gears and the planet gears mounted on the sub assembly will mesh with the input ring gear.
8. Install the input sun gear into the area between the 3 input planet gears.
9. Apply a coating of grease to the cover o'ring and install it into the o'ring groove of the hub.

**NOTE:** *It may be helpful to stretch the o'ring out prior to assembly to avoid pinching or shearing when the cover is assembled.*

10. Apply a heavy coating of grease to the cover thrust washer and place it in the center counter bore of the cover. The grease will help keep it in the bore during assembly.

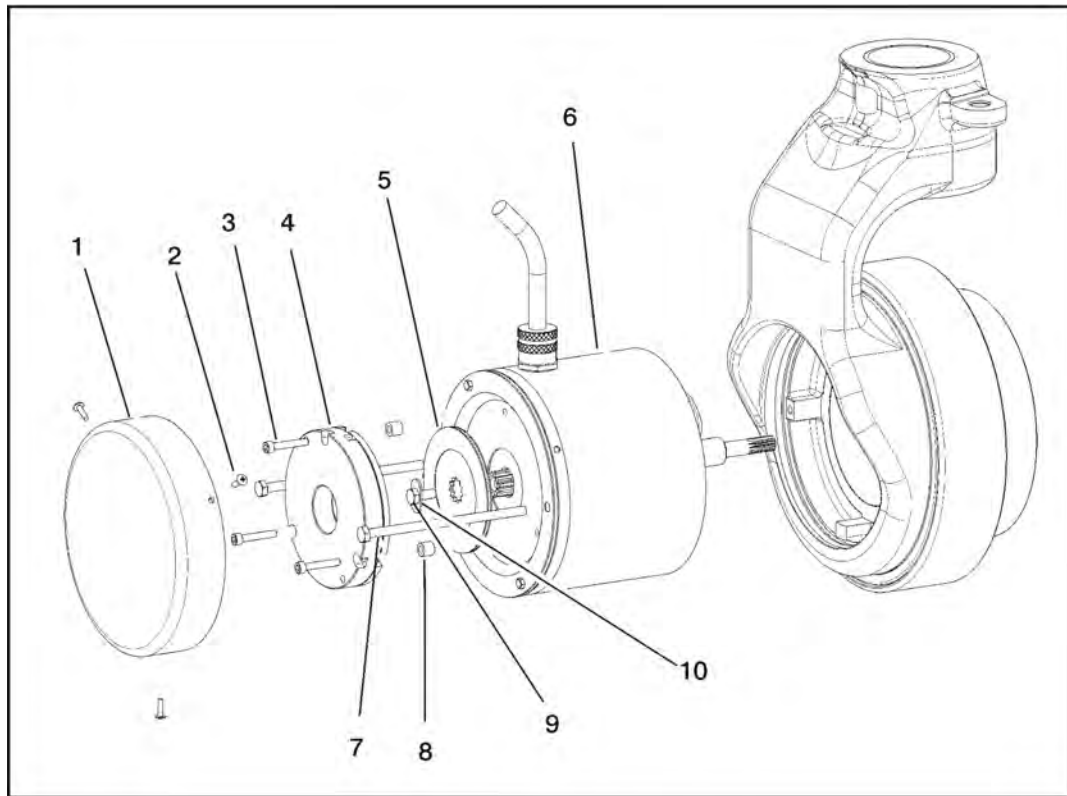
11. Center the cover in the hub bore so that the "JLG" logo is up. Push it into the bore.

**NOTE:** *Do not hit the cover with a hammer or mallet, shocks may cause the cover thrust washer to dislodge and drop into the gear cavity prior to the cover getting positioned properly. If all the parts are to size and assembled properly, the cover should not need excessive force to assemble.*

12. Install the cover retaining ring into the hub groove.



## Motor and Brake Assembly



- |                        |                   |                    |
|------------------------|-------------------|--------------------|
| 13. Brake Cover        | 17. 5. Disc Brake | 21. Retention Bolt |
| 14. Disengage Bolts    | 18. Motor         | 22. Washer         |
| 15. Socket Head Screws | 19. Thru Bolts    |                    |
| 16. Brake Housing      | 20. Spacers       |                    |

**Figure 3-18. Motor & Brake Disassembly**

**NOTE:** Applies only to:

USA machines built prior to S/N 0200118041,  
Belgium machines built prior to S/N 1200001487.

1. Remove back sealing cover from motor if it is not already removed.
2. Remove retention bolt and washer from the motor shaft end. **Do not let the armature shaft fall out of the open end of the motor.**
3. Open up Brake Kit. It should have a brake housing, brake disc, and three spacers.
4. Install Brake disc onto splined end of motor shaft.

**NOTE:** Keep the brake disc clear of any oil or grease.

5. Reinstall the retention bolt and washer into the shaft end to keep the armature in the motor.
6. Install the brake housing onto motor end cap; use the included spacers to space the brake housing

from the motor end. There may be motor wires in the way. Push them aside to mount the brake.

7. Fasten with 3 Bolts to a torque of 4 - 5 ft.-lbs.
8. Remove the disengage bolts from the brake housing and install them into the tapped holes in the motor end cap for storage.
9. Connect the connector (not shown) from the brake housing to the connector from the motor.
10. If not already done, remove thru bolts from motor.
11. Grease the motor O'ring (31) and install in the groove of the gearbox assembly. Also, apply grease to the lip of the motor shaft seal (17) in the gearbox.
12. Lift motor and line up the thru bolt holes with the tapped holes of the gearbox so that the motor orients with the strain relief behind the neck of the spindle.

### **SECTION 3 - CHASSIS & SCISSOR ARMS**

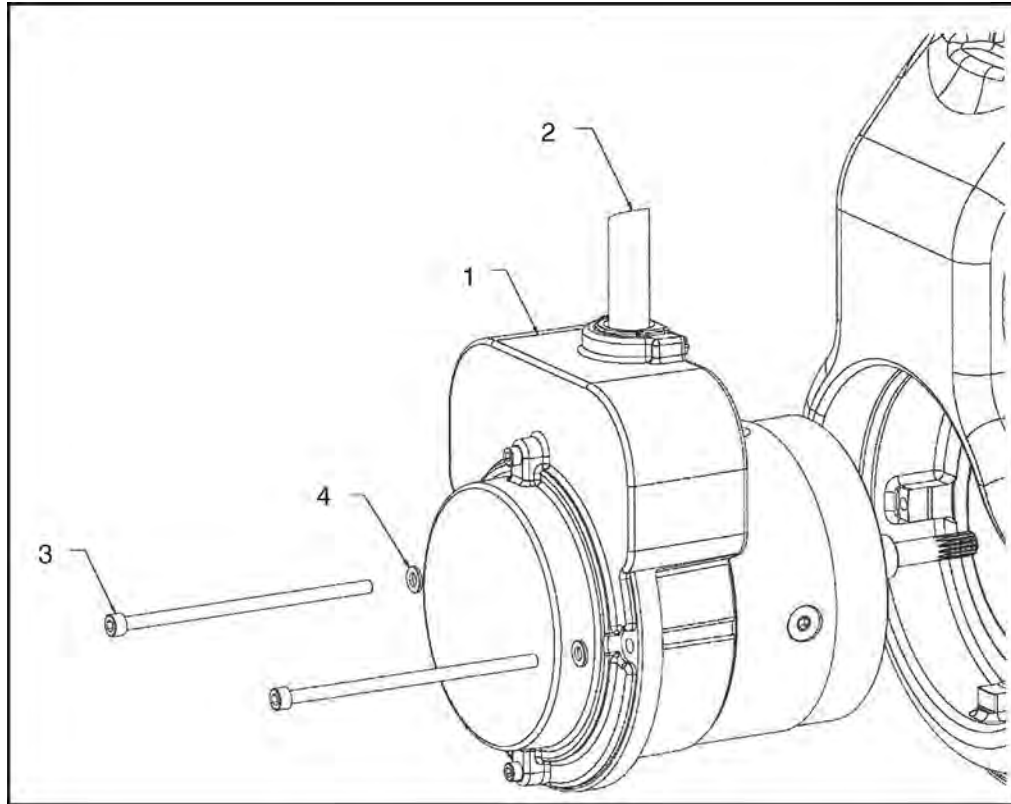
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13. Lower motor into the bore of the spindle. Motor may need to be tapped with a rubber mallet to get by the O'ring.
14. Install the thru bolts. Tighten to 9-11 ft.-lbs.

**NOTE:** *This is a blind assembly, make sure the specified torque is attained. If the torque is not attainable, then the thru bolt is not in the tapped hole. The motor will need to be aligned properly.*

15. Reinstall the back sealing cover onto the motor end.
16. Fill the gearbox with ISO grade 68 oil or oil of a similar viscosity (80W gear oil or 20W engine oil).

**Motor Assembly**



- |          |           |
|----------|-----------|
| 1. Motor | 3. Bolt   |
| 2. Cable | 4. Washer |

**Figure 3-19. Motor Assembly**

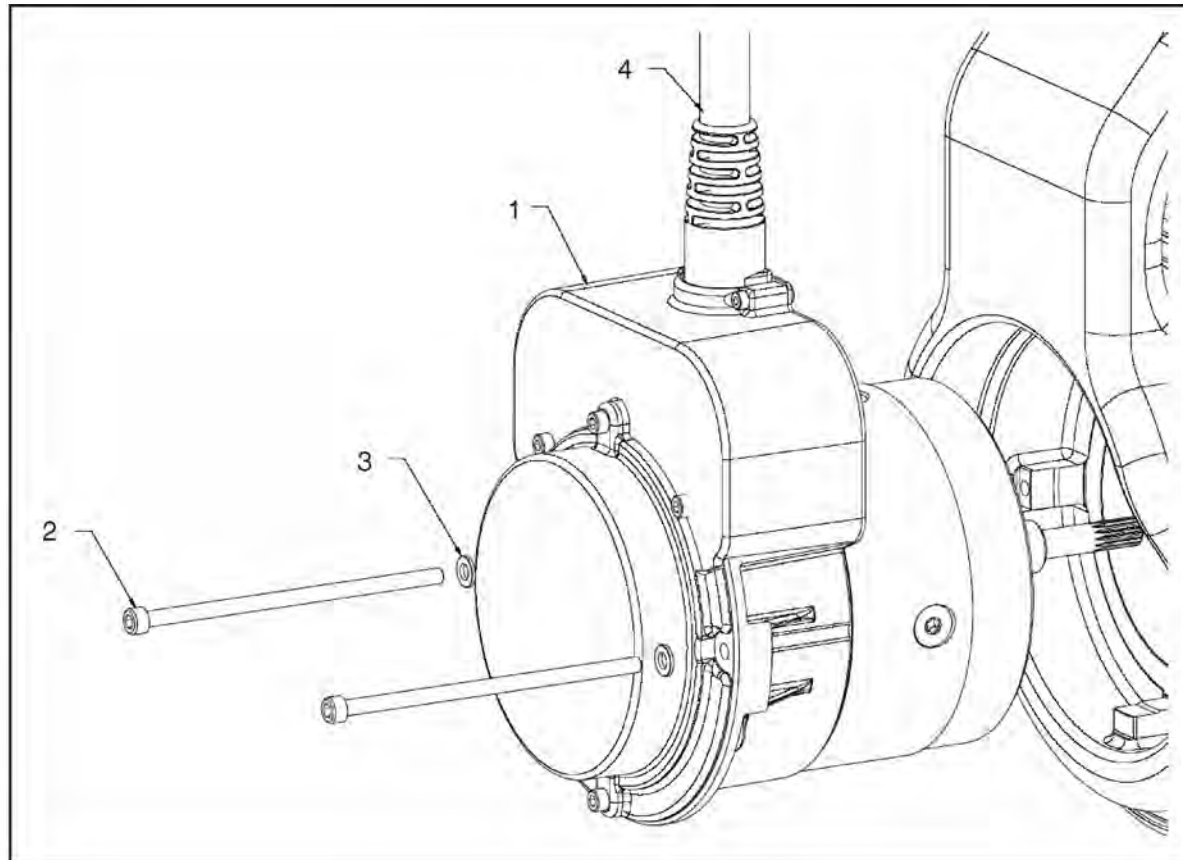
**NOTE:** Applies only to:  
 USA machines built S/N 0200152825 to S/N 020170585,  
 Belgium machines built S/N 1200008481 to S/N 1200015159.

1. Insert motor into back of gearbox. Motor will pilot on the four bosses in the gearbox. Try to keep the end of the motor shaft from causing damage to the lip seal in the gearbox.

**NOTE:** The motor may need to be rotated to line up the sun gear splines with the motor shaft splines.

2. Install the two motor mounting bolts. Torque to 9-11 ft-lbs (12 - 15 Nm).
3. Connect the end of the cable to the power control module.
4. Fill the gearbox with oil 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.

## Motor Assembly



- |                         |                |
|-------------------------|----------------|
| 1. Drive Motor          | 3. Washers     |
| 2. Motor Mounting Bolts | 4. Motor Cable |

**Figure 3-20. Drive Motor Assembly**

**NOTE:** Applies only to:

USA machines built S/N 0200170585 to Present,  
Belgium machines built S/N 1200015159 to Present.

1. Insert the drive motor into the back of the gearbox. The drive motor will pilot on the four bosses in the gearbox. Try to keep the end of the motor shaft from causing damage to the lip seal in the gearbox.

**NOTE:** The motor may need to be rotated to line up the sun gear splines with the motor shaft splines.

2. Install the two motor mounting bolts and washers. Torque to 9 - 11 ft-lbs (12 - 15 Nm).

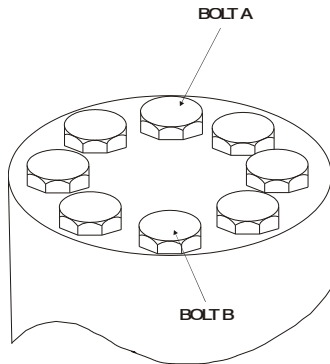
3. Connect the end of the Motor Cable to the Power Module.
4. Fill the gearbox with oil ISO grade 68 oil or oil of a similar viscosity (80W gear oil or 20W engine oil). The gearbox will need to be filled with 10 oz of oil.

### Tightening and Torquing Bolts

If an air impact wrench is used to tighten bolts, extreme care should be taken to ensure that the bolts are not tightened beyond their specified torque.

The following steps describe how to tighten and torque bolts or socket head cap screws in a bolt circle.

1. Tighten (but do not torque) bolt "A" until snug.
2. Go to the opposite side of the bolt circle and tighten bolt "B" until equally snug.
3. Crisscross around the bolt circle and tighten remaining bolts.
4. Now use a torque wrench to apply the specified torque to bolt "A".
5. Using the same sequence, crisscross around the bolt circle and apply an equal torque to the remaining bolts.



### Assembly Tools

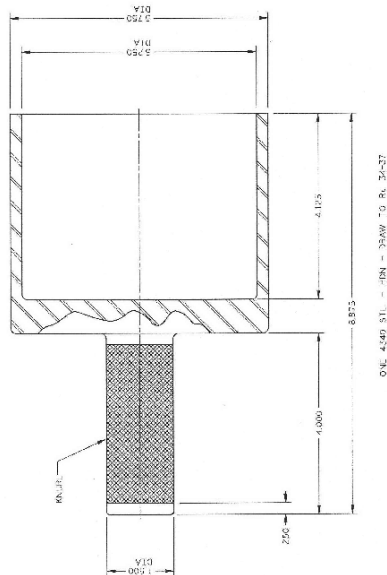


Figure 3-21. Assembly Tool 1

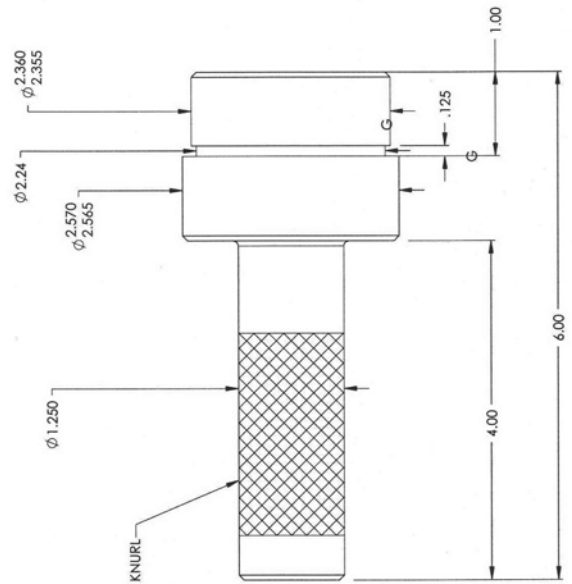


Figure 3-22. Assembly Tool 2

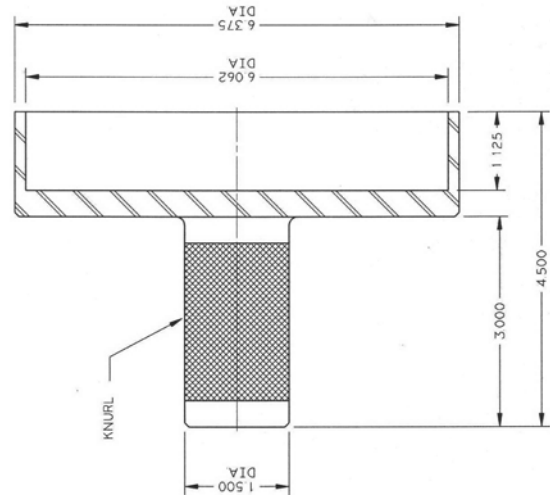


Figure 3-23. Assembly Tool 3

### 3.5 ELECTRIC DRIVE MOTOR

**NOTE:** The information contained within this section applies to the following machines:  
USA machines built S/N 0200152825 to S/N 020170585,  
Belgium machines built S/N 1200008481 to S/N 1200015159.

#### **WARNING**

**DISCONNECT THE BATTERY AND ALLOW THE MOTOR TO COOL DOWN BEFORE PERFORMING ANY MAINTENANCE. THE SURFACE TEMPERATURE OF THE MOTOR FRAME MAY CAUSE INJURY TO PERSONNEL.**

#### Disassembly

1. Disassemble the motor from the gearbox.
2. Mark the position of the motor end cap to the motor shell.
3. Remove the end cap retaining bolt.
4. Remove the retention bolt and washer from the end of the armature and remove armature from the motor shell.

**NOTE:** The load spring that is behind the motor bearing will be loose when the armature is removed. Take care not to lose it.

#### Replacing Motor Bearing

1. Carefully remove the bearing from the armature by using a bearing puller.
2. Support the armature securely, Using a sleeve pressing tool or a large socket press the bearing onto the end of the shaft until it bottoms out on the shoulder. The pressing tool must touch the bearing on the inner raceway.

#### Inspecting Motor Brushes

**NOTE:** Motor brushes should be inspected every 1000 hours.

1. Loosen the strain relief of the cable and push approximately 1 in. (25 mm) of cable into the motor.
2. Separate the end piece from the motor shell by approximately 1 in. (25 mm).
3. Using compressed air, clean the brush housing area of any accumulated carbon dust.
4. Remove the screw in each of the brush holders that connects the brush wires.
5. Remove each of the four brushes from the brush holder.
6. Inspect each brush, if the brush is equal to or less than 3/8 in. (9.5 mm), the brush will need replaced.

#### Replacing Motor Brushes

1. When installing new brushes, the motor commutator must be cleaned to allow for good brush contact. To do this, mount the armature in a lathe and take a skin cut on the commutator diameter.
2. Remove any copper chips that may have settled between the commutator bars.
3. Measure the diameter of the commutator. If the diameter is less than 2.8 in. (70.5 mm) the commutator can no longer be used.
4. Measure the depth of the commutator mica (commutator bar insulation). Verify that the depth of the mica is at least .016 in. (0.4 mm). If the depth is too shallow, undercut the mica to a maximum depth of 0.048 in. (1.2 mm). After undercut, clean the armature of any loose mica.
5. Install the new brushes into the brush holders. Make sure the brush is in the correct orientation to make smooth contact on the commutator.
6. Connect the brush wires to the terminal on the brush holder using the bolts that were removed earlier.
7. Pull each brush spring so that it is contacting the side of the brush. Push the brush springs towards the outside of each brush box so that the armature can be reassembled.

#### Replacing the Motor Cable

1. Using a knife, remove the shrink tubing from the cable butt splices that stick through a cast hole in the motor cap end.
2. Mark the brush leads at each splice according to the color of the cable lead that it is connected to.
3. Cut the leads going into each butt splice.

**NOTE:** Be sure to cut the leads just below the splice to leave as much cable as possible.

4. Cut off the motor connector that connects to the brake.
5. Remove the motor end cap from the motor shell.
6. Using a knife, remove the shrink tubing that is on the field lead butt splices. There should be 2 splices.
7. Mark the field leads going into each splice according to the color of the cable lead.
8. Cut the leads going into each butt splice.

**NOTE:** Be sure cut the leads just below the splice to leave as much cable as possible.

9. Remove the old cable from the motor shell.
10. Install the new motor cable into the motor shell through the strain relief such that the end of the

cable with the terminals is outside of the motor shell. Turn the cable so that the orange and blue wires are facing the field coils.

11. Push the cable in so that the outer jacket is flush with the bottom of the strain relief. Reassemble the strain relief to clamp the cable in place.
12. Using small butt splices and small shrink tubing, connect the field wires (orange and blue) with the appropriate marked wires coming from the field coils.
13. Connect the armature wires (2 red and 2 black) to the appropriately marked brush leads using the large butt splices and shrink tubing.
14. Pull each of the 4 armature slices through the access holes in the motor end cap.
15. Pull the brake leads (yellow and brown) through the access hole in the motor end cap.
16. Install the connector for the brake onto the yellow and brown leads. The leads can go with either of the connector pins.

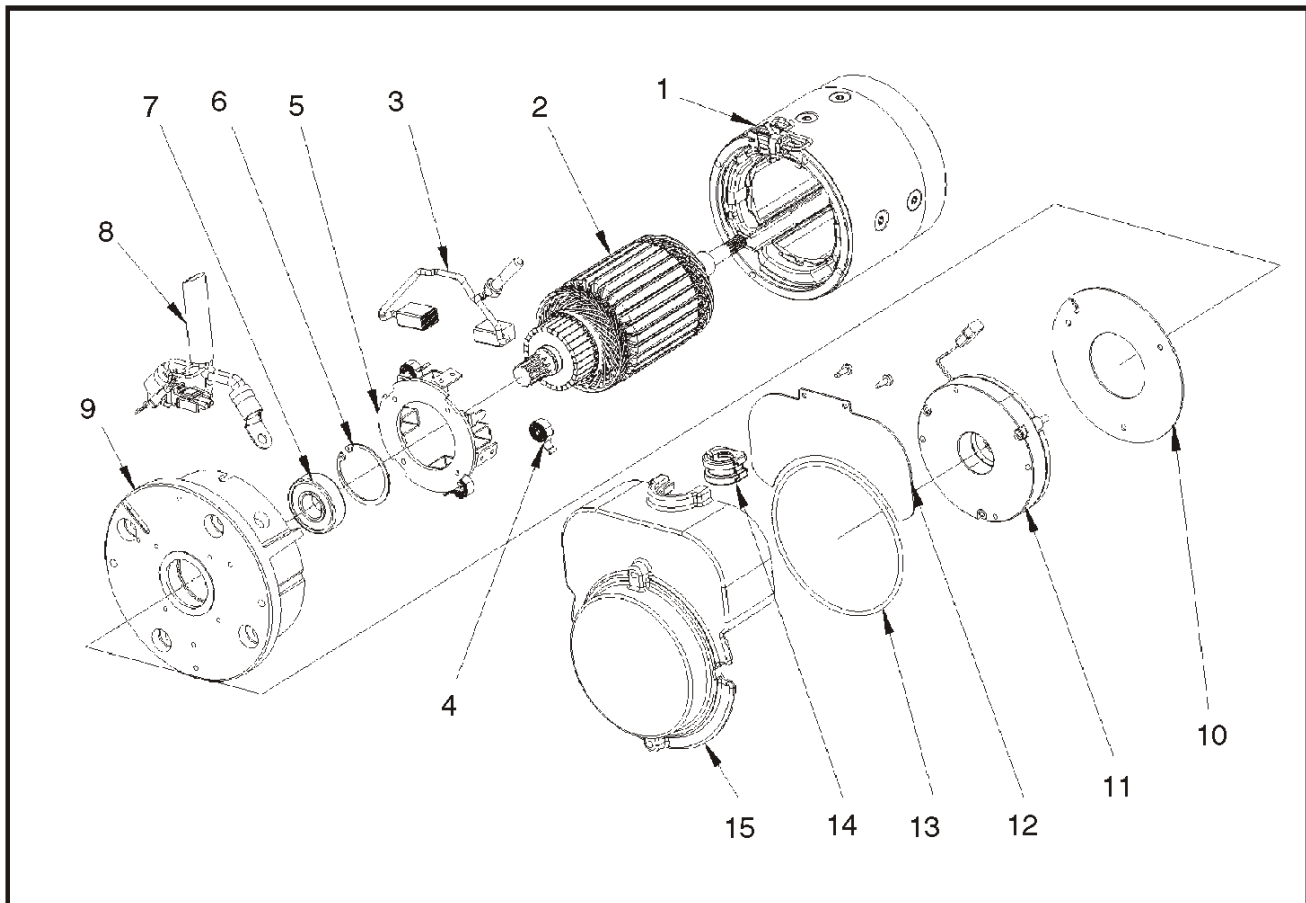
### **Reassembling the Motor**

1. Install the armature through the motor shell and into the separated end cap. Retain the armature in the end cap with the retention bolt.
2. Using a small brush hook or similar tool, pull each of the brush springs so that they are contacting the back of the brushes and are pushing the brush down on the commutator.
3. Push the end cap back into the motor shell. Line up the marks made in the disassembly instructions. Install the end cap retaining bolt to hold the parts together.

**NOTE:** *Take care not to pinch any wires in the interface of the end cap and motor shell. Cable access may need to be pulled out of the strain relief to get the parts assembled.*

4. Reassemble the strain relief onto the cable.
5. Reassemble the motor to the gearbox per assembly instructions shown in the motor and brake disassembly in this section.
6. After both motors are serviced, jack up the drive wheels of the scissor lift and drive the wheels under no load for approximately 10 minutes to seat the brushes, if the brushes have been replaced.

Motor Maintenance



- |                                |                           |
|--------------------------------|---------------------------|
| 1. Frame and Field Assembly    | 9. Commutator End Head    |
| 2. Armature Assembly           | 10. Friction Disc         |
| 3. Brush and Terminal Assembly | 11. Brake Assembly        |
| 4. Brush Spring                | 12. Cover Plate           |
| 5. Brush Box Assembly          | 13. O-Ring                |
| 6. Retaining Ring              | 14. Strain Relief Bushing |
| 7. Bearing                     | 15. Cover                 |
| 8. Wire Harness                |                           |

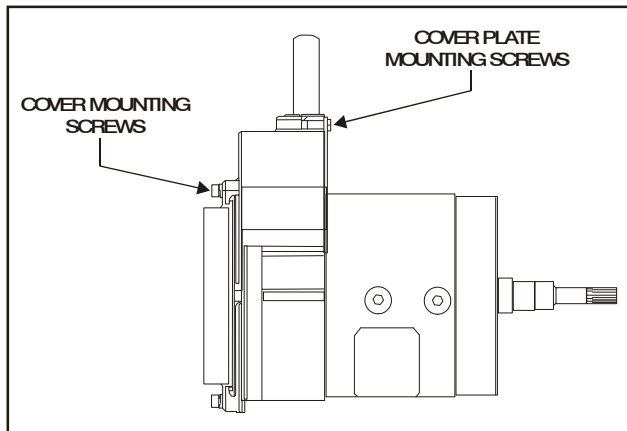
Figure 3-24. Drive Motor



**NOTE:** A well-planned maintenance program will save many hours of future down time and expense on a piece of equipment. Periodic maintenance consisting of inspections of motors, batteries and wiring circuitry is recommend.

**CAUTION**

**EYE PROTECTION SHOULD BE WORN DURING ANY MAINTENANCE OPERATION.**

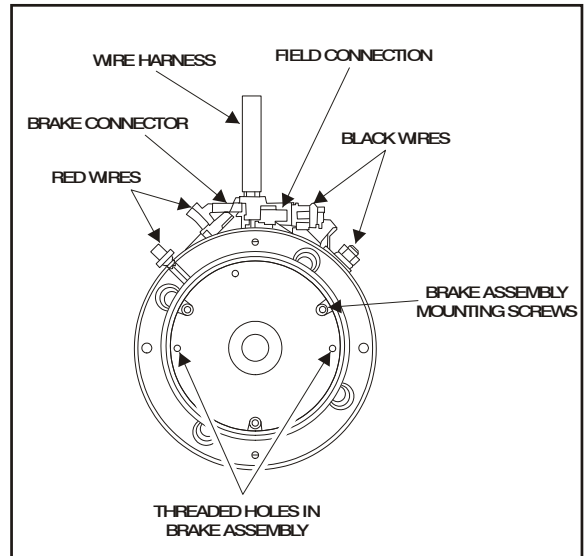


**Figure 3-25. Motor Side**

**Disassembly**

1. Remove the 2 (#8-32UNC x.50 in long) screws holding the cover plate in place and remove the cover plate from the motor.
2. Remove the 2 (M5 x 0.8 x 20mm long) screws holding the cover (15) in place and set aside. These screws are needed later to manually release the brake. Slide the strain relief bushing (14) and wire harness out of the cover and remove the cover from the motor. Remove strain relief bushing from wire harness and set aside.

3. Discard the O-ring (13) located inside the cover.



**Figure 3-26. Motor Front**

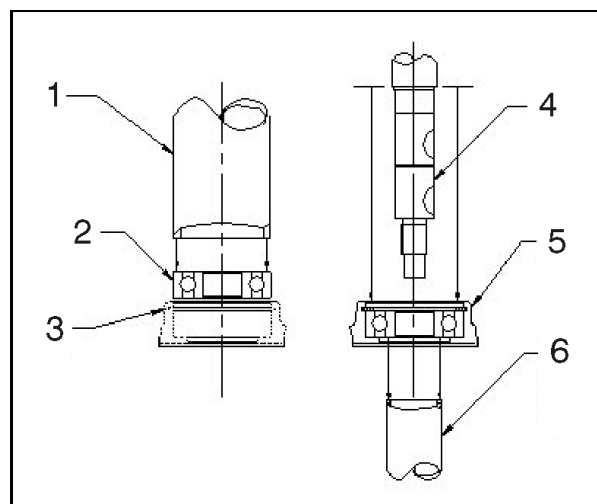
4. Remove the wire harness (8) from the motor by disconnecting the field connection and brake connection. Install the 2 cover mounting screws into the threaded holes in the brake assembly and tighten to manually release the brake. See Figure 2 below or image in the "Manual Disengage Procedure" on page 8 of the gearbox section of this manual.
5. Remove the 3 screws holding the brake assembly (11) to the motor. Carefully remove the brake assembly and friction disk (10) from the motor by sliding it off of the shaft.
6. Remove the screws holding the commutator end head (9) in place and remove the commutator end head from the frame and field assembly (1). The armature (2) will be attached to the commutator end head.
7. Pull back the brush springs (4) in the commutator end head, pull the brush back and rest the springs on the side of the brush. The brushes should move freely within the holders.
8. Use an arbor press or a bearing puller to remove the armature from the commutator end head assembly.
9. Remove the snap ring (6) and bearing (7) from the commutator end head. Discard the bearing.

**Inspection and Service**

1. Carefully blow out any accumulated carbon dust and dirt from the end head and the frame assembly using clean, oil free, compressed air.
2. Replace brushes (3) that are worn below their usable length (0600 in.), show signs of uneven wear or signs of overheating, such as discolored brush shunts and brush springs. Brushes should always be replaced in complete sets of four or eight. Use identical replacement parts; do not substitute brush grades as the brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause premature failure and excessive brush wear.
3. Make sure the brush box assembly (5) is tight on the commutator end head. Replace brush box assemblies in the commutator end head if they are physically damaged or brush holders are loose on the brush plate.
4. Visually inspect the frame and field assembly (1) for overheating or other signs of damage. Check all wiring to insure that the insulation is in good condition. Verify that pole screws are torqued to 250-300 in-lb [28.2-33.9 N-m]. Verify field resistance using a suitable ohmmeter per the appropriate motor specification. Verify that the field is electrically isolated from the frame using a dielectric tester. Replace as necessary.
5. Visually inspect the armature (2) assembly for signs of overheating or physical damage. Visually inspect the seal surface of the shaft for excessive wear. Check for grounded circuits using a dielectric tester by applying voltage between the commutator and the shaft. Visually inspect the commutator for excessive wear and overheating. Replace as necessary.
6. Visually inspect the brake surfaces for excessive wear. Remove any RTV Silicone sealant that may be present on the friction disc, cover, or commutator end head. Replace brake assembly (11) if necessary.
7. Visually inspect the wire harness (8) for frayed insulation, loose terminals, or other damage. Replace as necessary.

**Reassembly**

1. After inspection and servicing, reassemble the wiring in the commutator end head (9) as originally found. Ensure the wiring does not contact metal parts and that it allows the brushes to move unrestricted in the holders. Motor terminals must be assembled as shown Figure 4. Torque bottom terminal nut to 110-140 in-lb. (12.4-15.8 Nm).
2. After the motor has been disassembled, it is recommended that new bearings be installed because bearings may have been damaged during removal. Although the bearings may appear and feel good, the bearing races could be "brinelled" (races or balls deformed) and may exhibit noise and vibration problems or fail within a relatively short period of service. Press a new bearing into the commutator end head, pressing on the outer race only. See Figure 3. Replace the snap ring (6) in the snap ring groove.



1. Press Fixture must press against Outer Race
2. Bearing
3. End Head (held stationary)
4. Armature Assembly
5. Assembled End Head, Bearing, and Retaining Ring
6. Press Fixture must press against Inner Race (held stationary)

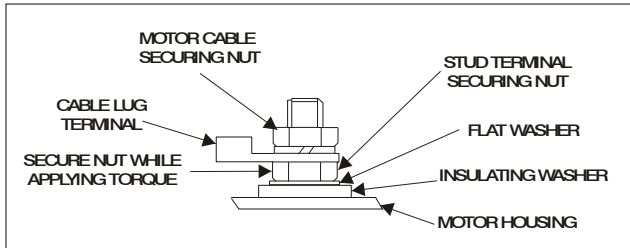
**Figure 3-27. Bearing Pressure Guidelines**

3. Press the armature (2) commutator end into the commutator end head and bearing assembly, carefully supporting the inner-race of the bearing. See Figure 3.
4. Carefully release the brush springs (4) allowing the brushes to contact the commutator. Make sure

brush shunts do not interfere with spring movement.

5. Assemble the commutator end head to the frame and field assembly (1) and tighten the screws to 120-140 in-lb. [13.6-15.8 N-m]. Make sure to align the field connection with the notch in the commutator end head. Seal wires where they exit from commutator end head with a small amount of RTV Silicone Sealant.
6. Align wires from brake assembly (11) into notch in friction disc (10). Install both items onto shaft of motor aligning wires with groove in commutator end head. Secure brake assembly to commutator end head using 3 bolts and apply small bead of RTV Silicone sealant around wires between friction disc and commutator end head and in notch in friction disc.

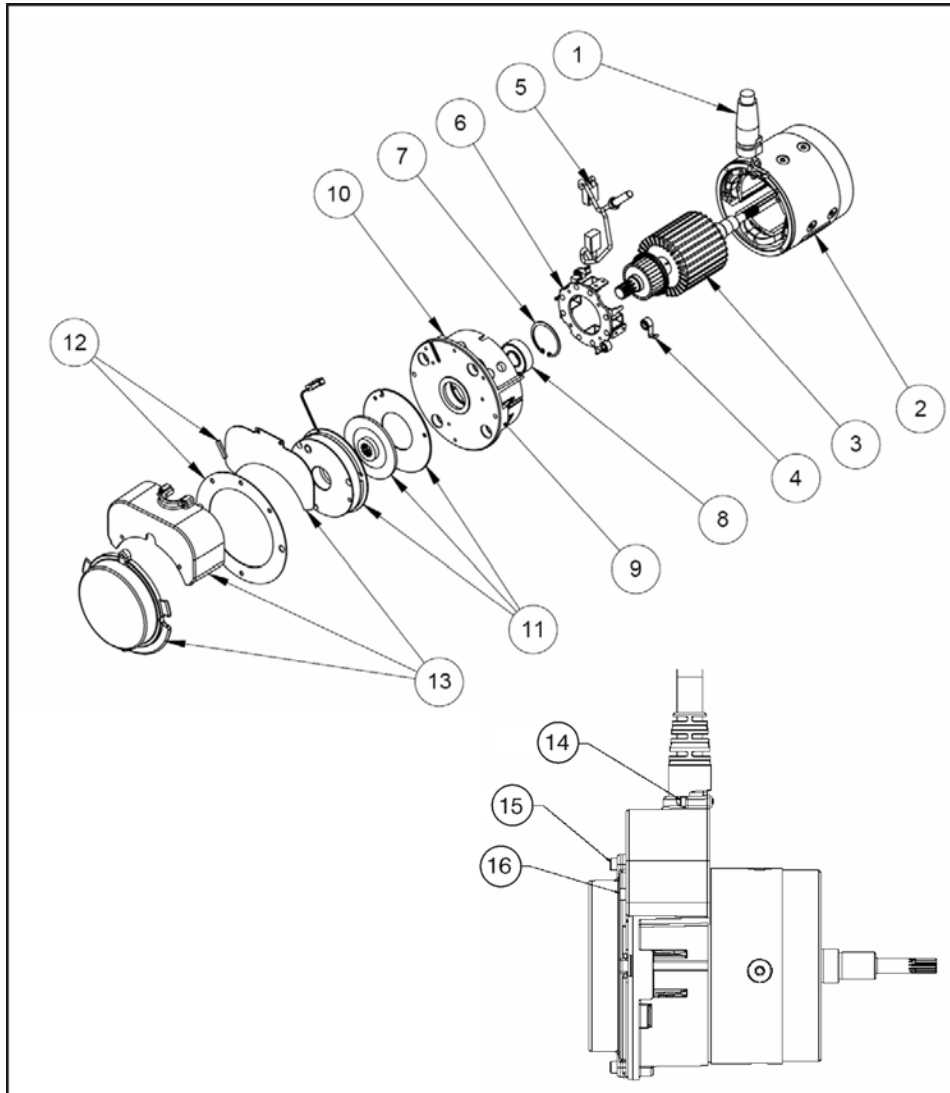
7. Install wire harness (8) to motor by connecting the field and brake connectors and securing the armature terminals to the terminal studs. Refer to Figure 2 for proper connections. Motor terminals must be assembled as shown in the figure above. **Always secure the bottom nut with a wrench as you tighten the top nut.** Torque top nut to 90-110 in-lb. [10.2-12.4 N-m].
8. Remove manual release screws from brake assembly. Apply new o-ring (13) and affix cover (15) to motor using the 2 manual release screws. A small dab of RTV Silicone sealant may be used to secure the o-ring into the o-ring groove in the cover to aid in assembly.
9. Assemble strain relief bushing (14) around jacket of wire harness and slide into slot in cover.
10. Align cover plate (12) with groove in frame and field and affix using 2 screws.



**Figure 3-28. Terminal Tightening**

**3.6 ELECTRIC DRIVE MOTOR**

**NOTE:** Applies only to:  
 USA machines built S/N 0200170585 to Present, Belgium machines built S/N 1200015159 to Present.



- |                              |                        |                                    |
|------------------------------|------------------------|------------------------------------|
| 1. Wire Harness              | 7. Retaining Ring      | 13. Cover Plate Kit                |
| 2. Frame & Field Assembly    | 8. Bearing             | 14. Cover Plate Mounting Screws    |
| 3. Armature Assembly         | 9. Commutator End Head | 15. Brake Cover Mounting Screws    |
| 4. Brush Spring              | 10. Grommet            | 16. Terminal Cover Mounting Screws |
| 5. Brush & Terminal Assembly | 11. Brake Assembly     |                                    |
| 6. Brush Box Assembly        | 12. Gasket Seal Kit    |                                    |

**Figure 3-29. Drive Motor Components**

**NOTE:** Reference Figure 3-29., Drive Motor Components for part names and locations when servicing the Drive Motor.

Periodic maintenance consisting of inspections of motors, batteries and wiring circuitry is recommended.

**⚠ CAUTION**

**ALWAYS WEAR EYE PROTECTION DURING ANY MAINTENANCE OPERATION.**

**Drive Motor Troubleshooting**

1. Turn off power to unit and disconnect main battery power. Disconnect drive motor connections from the Power Module.
2. Verify field continuity between the blue and orange wires. If available, use a 4-wire ohmmeter to verify the field resistance per the applicable motor specification below.
3. Verify armature continuity between the red and black wires. If available, use a 4-wire ohmmeter to verify the field resistance per the applicable motor specification below.

Model	Field Resistance @ 75°F (24°C)	Armature Resistance @ 75°F (24°C)
1930ES	0.210hms	0.0370hms
2030ES/2630ES/2646ES/3246ES	0.1270hms	0.0510hms

4. Using a dielectric tester, verify that there are no shorts between the following items:
  - a. Field connector pins and the case of the motor.
  - b. Armature terminals and the case of the motor.
  - c. Field connector pins to the armature terminals.
5. Verify continuity in 2 pin brake connector (yellow and brown wires). Measure the brake resistance and verify that it is between 18 and 22 Ohms.

**Drive Motor Disassembly**

**NOTE:** Refer to Figure 3-29.

1. Remove the two Cover Plate Mounting Screws (14) holding the Cover Plate (13) in place and remove the cover plate from the motor.
2. Remove the Brake Cover Mounting Screws (15) holding the Brake (11) in place and set aside. These screws are used to manually release the brakes.
3. Remove the two Terminal Cover Mounting Screws (16). Slide the strain relief of the Wire Harness (1) out of the cover and remove the cover from the motor.

4. Discard the Gasket (12) that was located under the brake and terminal covers.
5. Remove the wire harness from the motor by disconnecting the brake connection and armature connections. Cut the field connection close to the crimp connection on the motor side.
6. Install the two Brake Cover Mounting Screws (15) into the threaded holes in the brake assembly and tighten to manually release the brake (see Figure 3-10.).
7. Remove the three screws holding the brake assembly to the motor. Carefully remove the brake assembly, brake disc and reaction disc from the motor by sliding off of the shaft.
8. Remove the screws holding the Commutator End Head (9) in place and remove the commutator end head from the frame and field assembly. The Armature (2) will be attached to the commutator end head.
9. Pull back the Brush Springs (4) in the commutator end head, pull the brush back and rest the springs on the side of the brush. The brushes should move freely within the holders.
10. Use an arbor press or a bearing puller to remove the armature from the commutator end head assembly.
11. Remove the Snap Ring (7) and Bearing (8) from the commutator end head. Discard the bearing.

**Drive Motor Inspection and Service**

**NOTE:** Refer to Figure 3-29.

1. Carefully blow out any accumulated carbon dust and dirt from the Commutator End Head (9) and the Frame & Field Assembly (2) using clean, oil free, compressed air.
2. Replace Brushes (5) that are worn below their usable length of 0.6 in (1.5 cm), show signs of uneven wear or signs of overheating, such as discolored brush shunts and brush springs. Brushes should always be replaced in complete sets of four. Use identical replacement parts; do not substitute brush grades as the brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause premature commutator failure and excessive brush wear.
3. Make sure the Brush Box Assembly (6) is tight on the commutator end head. Replace brush box assemblies in the commutator end head if they are physically damaged or brush holders are loose on the brush plate.
4. Visually inspect the frame and field assembly for overheating or other signs of damage. Check all wiring to ensure that the insulation is in good con-

## SECTION 3 - CHASSIS & SCISSOR ARMS

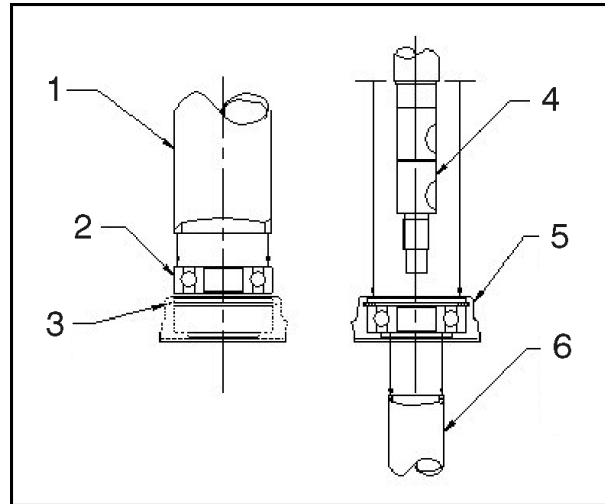
dition. Verify that pole screws are torqued to 250 - 300 in-lb (28.2 - 33.9 Nm). Verify field resistance using a suitable ohmmeter per the appropriate motor specification. Verify that the field is electrically isolated from the frame using a dielectric tester. Replace as necessary.

5. Visually inspect the Armature Assembly (3) for signs of overheating or physical damage. Visually inspect the seal surface of the shaft for excessive wear. Check for grounded circuits using a dielectric tester by applying voltage between the commutator and the shaft. Visually inspect the commutator for excessive wear and overheating. Replace as necessary.
6. Visually inspect the brake surfaces for excessive wear. Replace Brake Assembly (11) if necessary.
7. Visually inspect the Wire Harness (1) for frayed insulation, loose terminals, or other damage. Replace as necessary.

### Drive Motor Reassembly

**NOTE:** Refer to Figure 3-29.

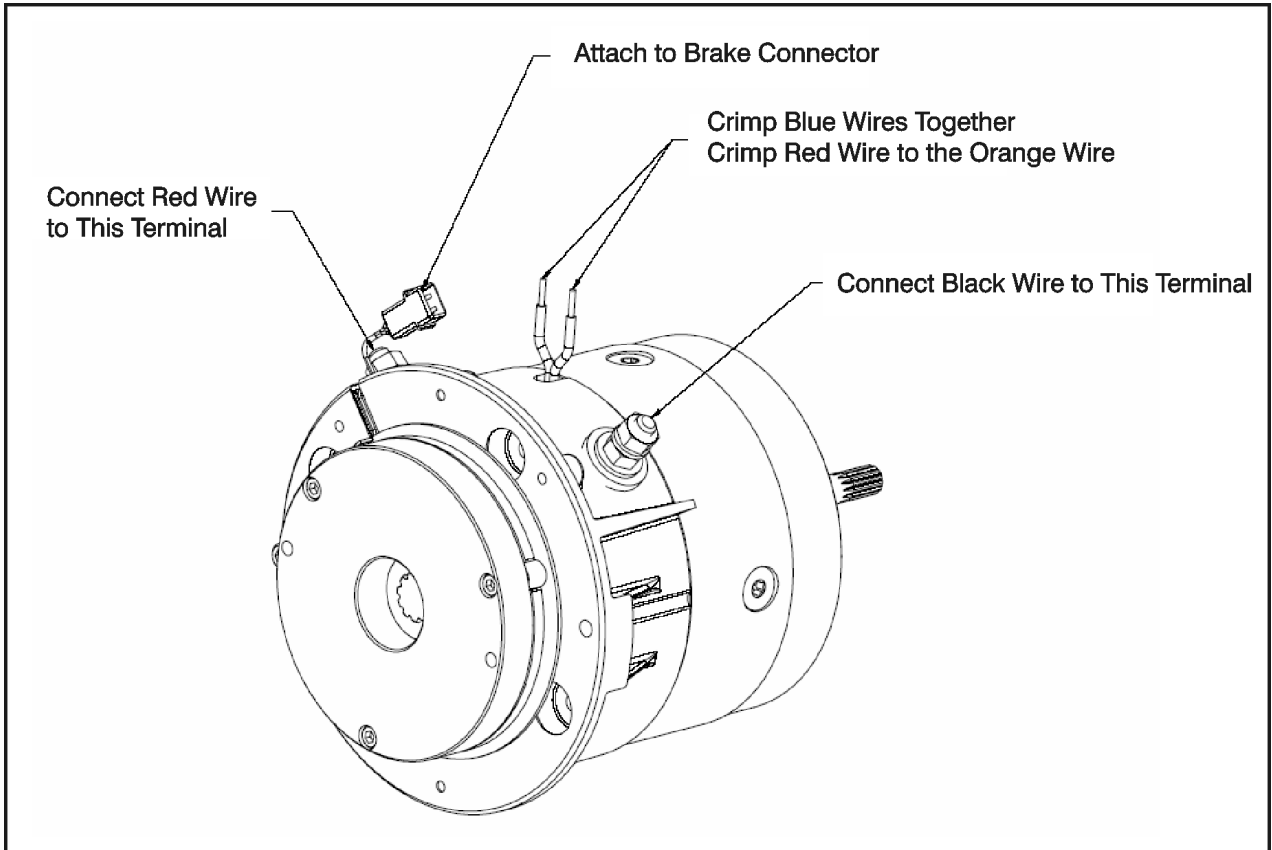
1. After inspection and servicing, reassemble the wiring in the Commutator End Head (9) as originally found. Ensure the wiring does not contact metal parts and that it allows the brushes to move unrestricted in the holders. Motor terminals must be assembled as shown Figure 3-31. Torque bottom terminal nut to 110 - 140 in-lb (12.4 - 15.8 Nm).
2. After the motor has been disassembled, it is recommended that new bearings be installed because bearings may have been damaged during removal. Although the bearings may appear and feel good, the bearing races could be "brinelled" (races or balls deformed) and may exhibit noise and vibration problems or fail within a relatively short period of service. Press a new bearing into the commutator end head, pressing on the outer race only. See Figure 3-27. Replace the Retaining Ring (7) in the retaining ring groove.
3. Press the Armature (3) commutator end into the commutator end head and bearing assembly, carefully supporting the inner-race of the bearing. See Figure 3-27.
4. Carefully release the Brush Springs (4) allowing the Brushes (5) to contact the commutator. Make sure brush shunts do not interfere with spring movement.



1. Press Fixture must press against Outer Race
2. Bearing
3. End Head (held stationary)
4. Armature Assembly
5. Assembled End Head, Bearing, and Retaining Ring
6. Press Fixture must press against Inner Race (held stationary)

**Figure 3-30. Bearing Pressure Guidelines**

5. Assemble the commutator end head to the Frame & Field Assembly (2) and tighten the screws to 120 - 140 in-lb (13.6 - 15.8 Nm). Make sure to align the field connection with the notch in the commutator end head. Seal wires where they exit from commutator end head with the Grommet (10).
6. Place the Gasket Seal (12) in the bottom of the notch in the commutator end head. Align wires from the Brake Assembly (11) into the notch in the commutator end head. Secure brake assembly to commutator end head using three bolts.
7. Install Wire Harness (1) to motor by connecting the brake connectors and securing the armature terminals to the terminal studs. Crimp the field connection (red/orange to orange and blue to blue) together and heat shrink. Motor terminals must be assembled as shown in **Always secure the bottom nut with a wrench as you tighten the top nut.** Torque top nut to 90 - 110 in-lb (10.2 - 12.4 Nm).



**Figure 3-31. Wire Harness Connections**

8. Remove manual release screws from brake assembly. Apply new Gasket (12) and affix brake cover to motor using the 2 manual release screws.
9. Attach terminal cover to the commutator end head using two terminal cover screws.
10. Slide the strain relief of the wire harness into the slot of the terminal cover. Align cover plate with groove in frame and field and affix using two cover plate screws.

### Drive Motor Servicing Guidelines

Because the operating environment of industrial equipment varies widely, the following are suggested for periodic maintenance inspection intervals.

- **Normal Service** – Perform routine inspection (outlined in the Drive Motor Inspection and Service portion of this section) every 1,000 hours of drive time.
- **Severe Service** – Perform routine inspection every 500 hours of drive time. Severe service environments are listed below:
  - a. Dusty or dirty locations like cement plants, lumber and flour mills, coal mining, stone quarries, etc.
  - b. High temperature areas like steel mills, foundries, etc.
  - c. Environments with sudden temperature change, such as in refrigeration plant, etc.

### 3.7 DRIVE MOTOR ELECTRICAL EVALUATION

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

Refer to Figure 7-2., Resistance Measurement. Disconnect the Main Battery Disconnect and all drive motor cables during this analysis.

- **Resistance < 2 Ohms Red to Black Armature Wires.** The heavy red and black conductors are connected to the motor's armature winding. The winding is a very low impedance and should appear to be a short-circuit for an ordinary voltmeter. High resistance can signal corrosion, improper crimps, damaged cabling, worn brushes, a faulty commutator, or an open armature winding.
- **Resistance < 2 Ohms Blue to Orange Field Wires.** The blue and orange conductors are connected to the motor's field winding. In order to make this measurement, it will be necessary to disconnect the butt-splice on the two orange wires or use a piercing meter probe. As with the armature, the field is a very low impedance and should appear to be a short-circuit for an ordinary voltmeter. High resistance can signal corrosion, improper crimps, damaged connectors, damaged cabling, or an open field winding.
- **Resistance 15-25 Ohms Yellow to Brown Brake Wires.** The yellow and brown wires are connected to the integral brake. Improper resistance can signal corrosion, improper crimps, damaged cabling, or a faulty solenoid.
- **Resistance > 1 MegaOhms Red Armature Wire to Motor Housing.** The armature winding should be electrically isolated from the motor housing. Low resistance may be an indication of a crushed cable, a burned cable, or a burned armature winding. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).

- **Resistance > 1 MegaOhms Blue Field Wire to Motor Housing.** The field winding should also be electrically isolated from the motor housing. Low resistance may be an indication of a crushed cable, a burned cable, or a burned field winding. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).
- **Resistance > 1 MegaOhms Red Armature Wire to Blue Field Wire.** The armature and field windings should also be electrically isolated from one another. Low resistance may be an indication of a crushed cable, a burned cable, damaged windings. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).

### Servicing Guidelines

Since the operating environment of industrial equipment varies widely, the following are suggested for periodic maintenance inspection intervals.

- **Normal Service** – Perform routine inspection (outlined in the Inspection and Service portion of this section) every 1,000 hours of drive time.
- **Severe Service** – Perform routine inspection every 500 hours of drive time. Severe service environments are listed below:
  - a. Dusty or dirty locations like cement plants, lumber and flour mills, coal mining, stone quarries, etc.
  - b. High temperature areas like steel mills, foundries, etc.
  - c. Environments with sudden temperature change, such as in refrigeration plant, etc.



## Common Traction System Difficulties

### 1. Short-Circuit Motor Armature

This issue will allow the vehicle to drive very slowly or not at all. Rapid motor overheating (one motor) will result.

This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will exceed 120A. The FLD CUR display (Field Current Reading) will hover around 40A. Neither wheel will rotate at normal speed, but it will be possible to rotate the drive wheel by hand. The Power Module's self-diagnostics cannot detect this fault since the situation appears identical to climbing a steep grade.

To find the source of the difficulty, pull the Main Battery Disconnect and disconnect the Armature Wiring (heavy red and black conductors) from the suspected drive motor leading to the Power Module's M1 and M2 Terminals. Re-test the traction function. If the remaining drive motor is able to reach full speed (and Armature Current is less than 50A), the drive motor that has been disconnected is fault. Investigate for crushed and burned cables. Note if the drive motor smells burned.

### 2. Short-Circuit Brake Release

This issue will not allow the vehicle to drive. Rapid motor overheating (both motors) will result. Continued attempts to drive the vehicle may result in armature damage.

This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will exceed 120A. The FLD CUR display (Field Current Reading) will hover around 40A. Neither wheel will rotate, and it will be impossible to rotate either drive wheel by hand. The Ground Module cannot detect this fault during power-up or self-test since energizing the brakes could pose a hazard. However, it may detect this issue during Drive (investigate using JLG Analyzer).

To find the source of the difficulty, remove the rear cover from either drive motor. Insert voltmeter leads into the white connector leading to the brake solenoid (yellow and brown wires) and attempt to drive (Platform Mode). The Ground Module will apply approximately 24V to the brake release solenoids (wired in parallel) during drive, but will reduce this voltage in the event of a short-circuit. If this voltage is improper (less than 8V),

investigate using resistance measurement (refer to Drive Motor Electrical Evaluation). Suspect damaged cabling, burned cabling, or faulty brake release solenoids. Trace the brake release cabling from the Power Module Compartment to the Ground Module Connector J1-24.

### 3. Open-Circuit Brake Release

This issue will not allow the vehicle to drive. Rapid motor overheating (both motors) will result. Continued attempts to drive the vehicle may result in armature damage.

This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will exceed 120A. The FLD CUR display (Field Current Reading) will hover around 40A. It is possible that one wheel may rotate, or neither may rotate (depending on the location of the open-circuit). Listen for the brake release solenoid when activating drive. The Ground Module cannot detect this fault during power-up or self-test since energizing the brakes could pose a hazard. However, it may detect this issue during Drive (investigate using JLG Analyzer).

If one wheel rotates, the open-circuit is located in the wiring for that specific drive motor (Power Module compartment or Drive Motor Cable). Investigate for improper crimps, unlatched connectors, damaged cables, or open brake release solenoids (refer to Drive Motor Electrical Evaluation).

If neither wheel rotates, the open-circuit is located in the wiring between the Power Module compartment and Ground Module. Using a voltmeter, measure the brake release voltage on either brake connector in the Power Module compartment during drive (should be approximately 24V). Investigate for improper crimps, unlatched connectors, damaged harnessing, or a faulty Ground Module. As an alternative, insert a short piece of wire with a Deutsch Female Crimp directly into Ground Module's J1-24 and measure voltage as a diagnostic measure (eject vehicle harness from that pin).

3.8 POWER MODULE - SEVCON

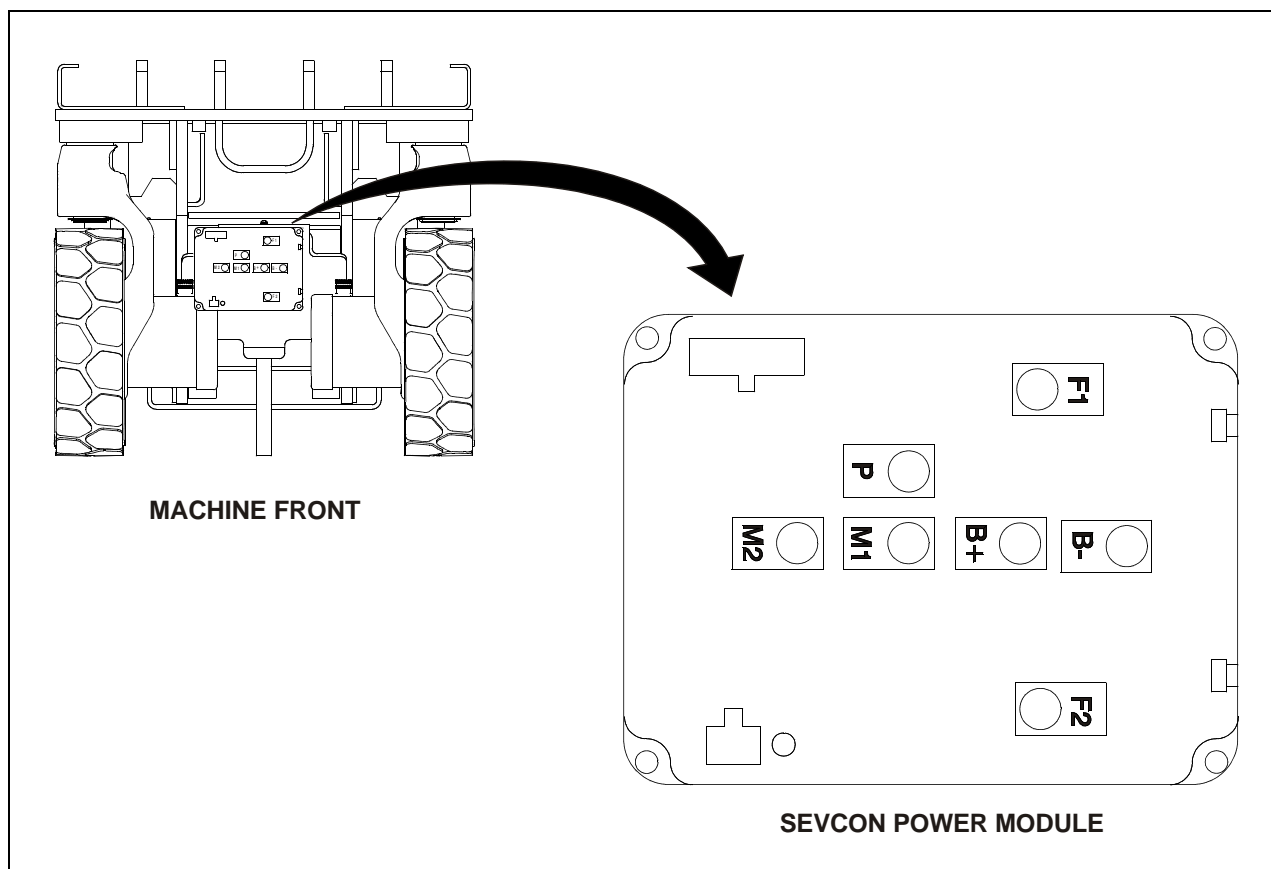


Figure 3-32. Sevcon Power Module Location

The Sevcon Power Module, P/N-1600346 was replaced by the ZAPI Power Module (See Figure 3-33.) on machines built starting in mid year 2010.

Table 3-1. Sevcon Power Module Specs

Operating Voltage (Pin 1 and B+)	14.5 to 40 VDC
Maximum Current Limits:	
Armature	350 A
Field	40 A
Pump	150 A
Standby Current	150 mA
Temperature Range:	
Operating	-30°C to 40°C
Storage	-40°C to 70°C
Thermal Limit	75°C to 90°C
Switching Frequency	16 kHz

The Power Module is located at the front of the machine as shown in Figure 3-32., Sevcon Power Module Location. Use the following instructions when replacing the Power Module.

1. Make sure power to the machine is turned off and the batteries are disconnected.

**NOTE:** Note the wire terminal locations when removing the old Power Module.

2. Disconnect all wires from the old Power Module and remove from the machine.
3. Before bolting the Power Module on, using a V-notch trowel, apply a layer of heat transfer grease to the back of the new Power Module.
4. Be sure that the terminals are oriented as shown.
5. After installing the new Power Module, begin connecting the wires back to the controller.
6. Torque the M6 terminal bolts to 5 ft-lb. (7 Nm). Torque the M8 terminal bolts to 7 ft-lb. (10Nm).
7. After all connections to the Power Module are made, the battery can be reconnected.

## Power Module Electrical Evaluation

Several basic electrical tests can be performed on the Power Module. Failure of one of these evaluations is significant and may indicate that the device is physically damaged. If a Power Module is suspected to be faulty, thoroughly examine the rest of the system for possible damage.

Refer to Figure 7-2., Resistance Measurement. Disconnect the Main Battery Disconnect and all cables from the Power Module during this analysis. Wait 60 seconds after power is disconnected to allow internal charge to dissipate (risk of hazard, improper readings otherwise).

- **Resistance >100kOhms all Terminals to Housing.** Ensure that there is an open-circuit between all terminals of the Power Module and the module's aluminum housing. The device is fully potted and all electronics are insulated from the housing. Place the Black meter lead on the housing and use the Red meter lead to probe all terminals.
- **Resistance < 2 Ohms between +B and M1.** Ensure that there is a short-circuit between the +B and M1 Terminals. Internally, there is a low-impedance current measurement shunt for the Armature portion of Traction. Place the Red meter lead on +B, and the Black meter lead on M1.
- **Resistance >1 MegaOhms between F1 and -B; F2 and -B.** Ensure that there is an open-circuit between the two Field Terminals (F1 & F2) and -B. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is un-powered. Place the Black meter lead on -B and the Red meter lead on F1 / F1.
- **Resistance >1 MegaOhms between F1 and +B; F2 and +B.** Ensure that there is an open-circuit between the two Field Terminals (F1 & F2) and +B. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is un-powered. Place the Black meter lead on +B and the Red meter lead on F1 / F1.
- **Resistance >100kOhms between P and -B.** Ensure that there is an open-circuit between the P and the -B Terminals. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is un-powered. Place the Black meter lead on -B, and the Red meter lead on P. Note that a measurement of increasing resistance (capacitor charge) is normal, but a persistently low impedance is not.
- **Resistance >1kOhms between M2 and -B.** Ensure that there is an open-circuit between the M2 and -B Terminals. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is un-powered. Place the Black meter lead on -B, and the Red meter lead on M2. Note that a measurement of increasing resistance (capacitor charge) is normal, but a persistently low impedance is not.
- **Resistance 120 Ohms between Pins 10 & 11.** Ensure that the resistor that terminates the CANbus is within tolerance between pins 10 and 11 on the 12 position Mini-Fit Jr (Connector "B"). Place the Red meter lead on pin 10, and the Black meter lead on pin 11. The resistance should measure between 110 - 130 Ohms.

3.9 POWER MODULE - ZAPI

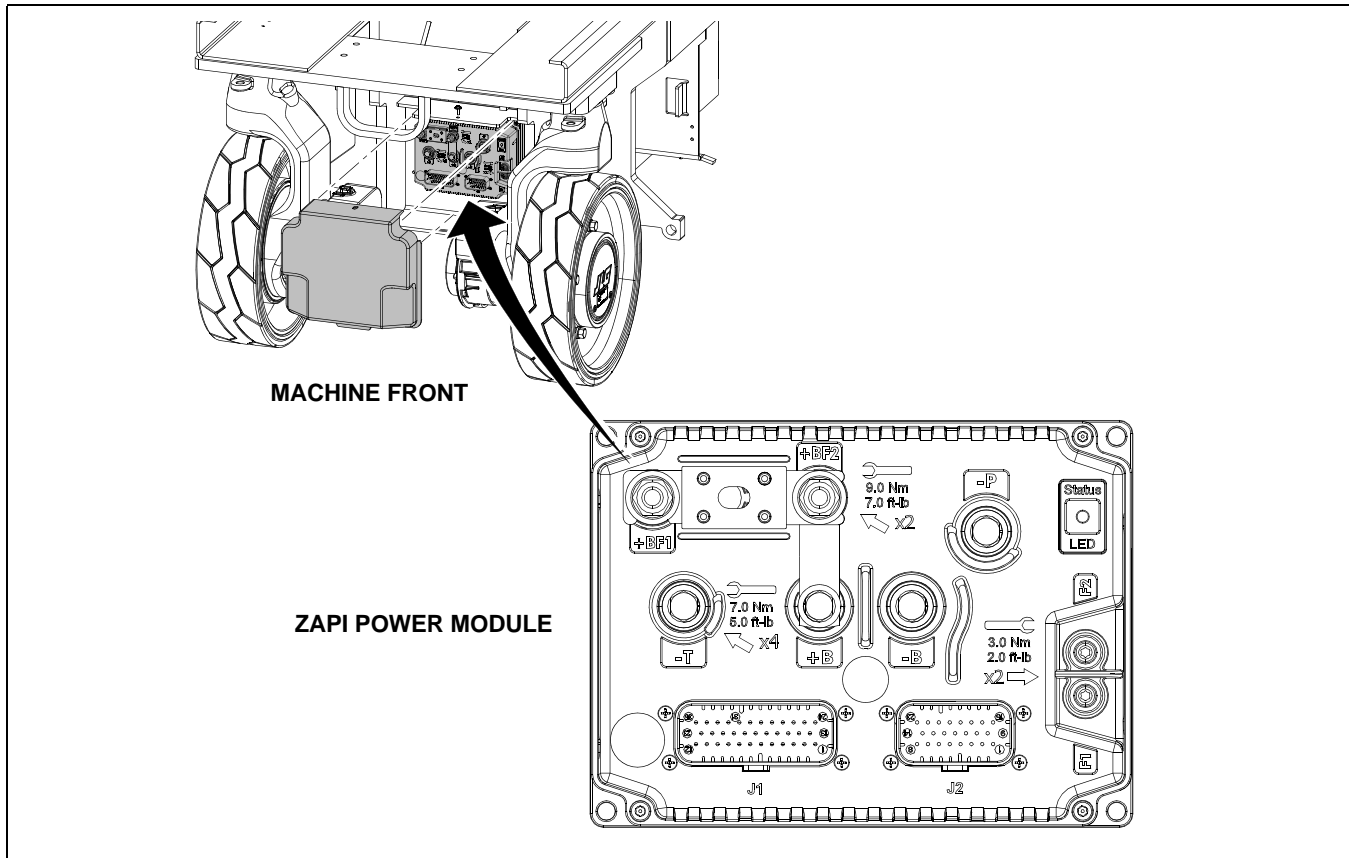


Figure 3-33. ZAPI Power Module Location

ES Scissors built starting in mid year 2010 replaced the Sevcon Power Module with the ZAPI Power Module (P/N-1001092456).

Table 3-2. ZAPI Power Module Specs

Operating Voltage (B+)	14.5 to 40 VDC
Maximum Current Limits:	
Armature	300 A
Field	40 A
Pump	180 A
Standby Current	150 mA
Temperature Range:	
Operating	-40°C to 75°C
Storage	-40°C to 125°C
Thermal Limit	75°C to 90°C
Switching Frequency	16 kHz

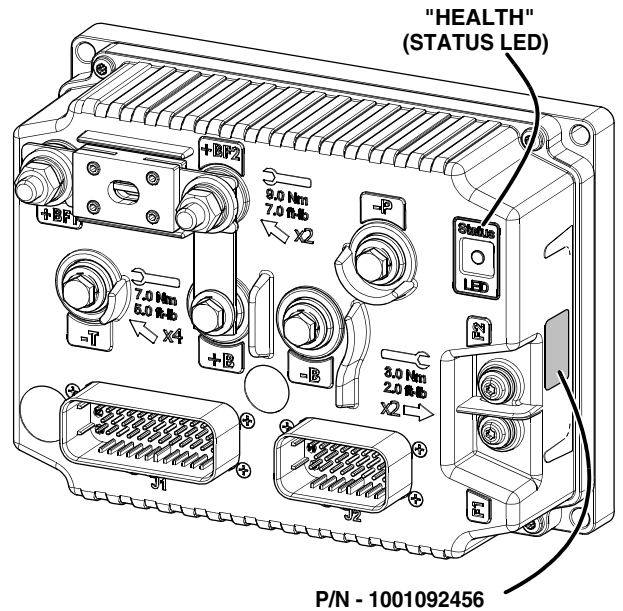
The power module is located behind a protective cover at the front of the machine as shown in Figure 3-33., ZAPI Power Module Location. Use the following instructions when replacing the power module.

1. Turn machine power off and disconnect the batteries.
2. Locate and remove the power module protective cover from the machine.
3. Note the wire terminal locations when removing the old power module.
4. Disconnect all wire connectors and cables from the old power module and remove it from the machine.
5. When installing the new power module, be sure that the terminals are oriented as shown in Figure 3-33.
6. After installing the new power module, begin connecting the wire connectors/cables to the module.
7. Torque all terminal bolts to torque specifications shown on the front of the module.
8. After all connections to the power module are made, the batteries can be reconnected.
9. Reinstall the power module cover, then check for normal machine operation.

## ZAPI Power Module Electrical Evaluation

### INTEGRATED HEALTH INDICATOR

The ZAPI Power Module provides a green STATUS LED that shines through the cover to indicate module "health" status. The LED shall be illuminated when the device is powered on. The LED blinks (2Hz) when an internal issue is detected that cannot be repaired by a technician. It should be noted that this will trigger replacement of the device.



ZAPI Power Module - "HEALTH" (Status LED)

### 3.10 BATTERY REMOVAL

#### 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.

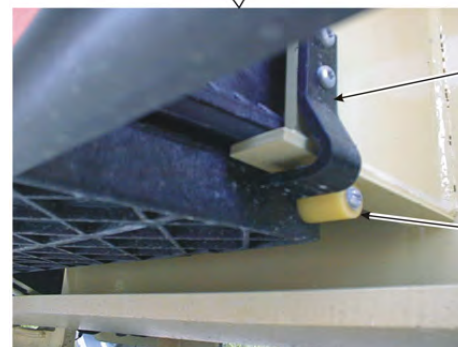
BATTERIES APPROVED BY JLG HAVE BEEN TESTED FOR COMPATIBILITY WITH THE ALGORITHM PROGRAMMING OF THE DELTA Q BATTERY CHARGER TO OPTIMIZE BATTERY LIFE AND MACHINE CYCLE TIMES. THE USE OF NON APPROVED BATTERIES IN YOUR JLG EQUIPMENT MAY RESULT IN PERFORMANCE ISSUES OR BATTERY CHARGER FAULT CODES. JLG ASSUMES NO RESPONSIBILITY FOR SERVICE OR PERFORMANCE ISSUES ARISING FROM THE USE OF NON APPROVED BATTERIES.

#### WARNING

BEFORE BATTERY REMOVAL CAN BEGIN, ENSURE THAT THE BATTERIES HAVE BEEN PROPERLY DISCONNECTED TO AVOID SERIOUS INJURY OR POSSIBLE DEATH.

1. Pull the battery door completely out and disconnect the batteries.
2. Rest the battery door onto the forks of a fork truck, or suitable lifting device. Be sure the forks or lifting device are properly centered over the weight of the battery door.
3. Using a phillips screwdriver, remove the battery door rollers located at the rear corners of the battery door.

4. Adjust the lifting device to take the weight of the battery door and remove door from under the machine.
5. Once the battery door is removed from the machine, battery replacement/maintenance can begin.
6. After any maintenance on the batteries or replacement of the batteries is complete lift the battery door back onto the machine.
7. Make sure the rollers are replaced and tight.
8. Reconnect batteries and check for proper operation.



**Battery Maintenance and Safety Practices**

**⚠ CAUTION**

ENSURE THAT BATTERY ACID DOES NOT COME INTO CONTACT WITH SKIN OR CLOTHING. WEAR PROTECTIVE CLOTHING AND EYEWEAR WHEN WORKING WITH BATTERIES. NEUTRALIZE ANY BATTERY ACID SPILLS WITH BAKING SODA AND WATER.

BATTERY ACID RELEASES AN EXPLOSIVE GAS WHILE CHARGING, ALLOW NO OPEN FLAMES, SPARKS OR LIGHTED TOBACCO PRODUCTS IN THE AREA WHILE CHARGING BATTERIES. CHARGE BATTERIES ONLY IN A WELL VENTILATED AREA.

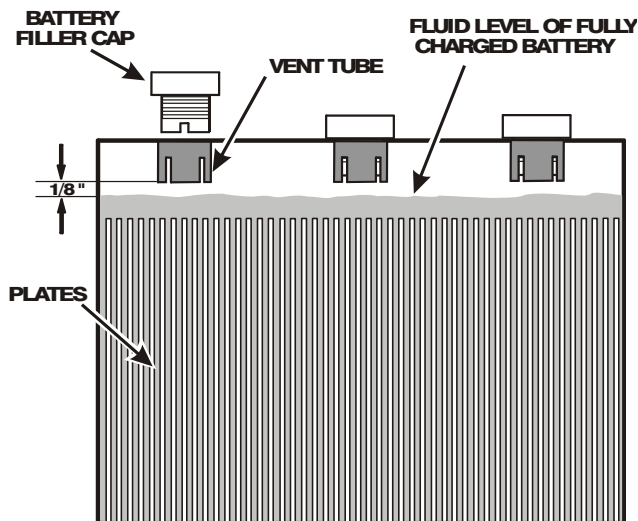
ADD ONLY DISTILLED WATER TO BATTERIES. WHEN ADDING WATER TO THE BATTERIES, A NON-METALLIC CONTAINER AND/OR FUNNEL MUST BE USED.

**⚠ 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.

Check the electrolyte level of the batteries often, adding only distilled water when required. When fully charged, battery fluid level should be 1/8" below vent tubes. (See Figure 3-34.).

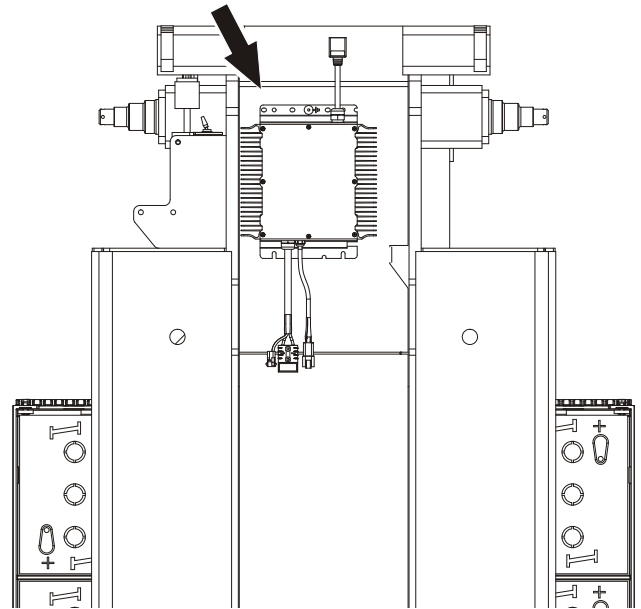
- DO NOT fill to bottom of vent tubes.
- DO NOT allow fluid level to go below the top of the plates when charging or operating.



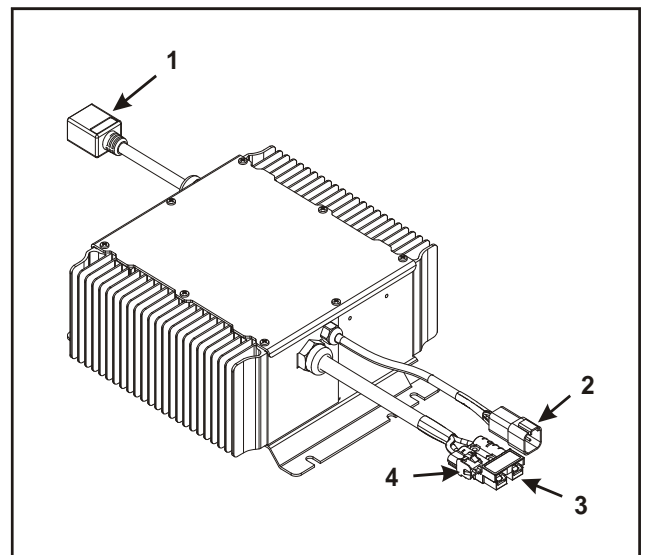
**Figure 3-34. Battery Fluid Level**

**3.11 BATTERY CHARGER**

The Battery Charger is located on the top of the chassis at the rear of the machine. Raise and secure scissor arms with arm prop to gain access to the charger.



**Figure 3-35. Battery Charger Location**



- |                             |                                |
|-----------------------------|--------------------------------|
| 1. AC Voltage - Input Cable | 3. DC Power Cable to Batteries |
| 2. Charger Interlock Cable  | 4. LED Indicator Cable         |

**Figure 3-36. Battery Charger**

**Table 3-3. Battery Charger Specs**

BATTERY CHARGER	SPECIFICATION
<b>OUTPUT</b>	
Nominal DC Output Voltage	24V
Maximum DC Output Voltage	33.6V
Maximum DC Output Current	25A
Maximum Interlock Current	20A
<b>INPUT</b>	
AC Input Voltage	85-265VAC
Nominal AC Input Voltage	120VAC - 230VAC RMS
AC Input Frequency	45-65 HZ
Maximum AC Input Current	12A RMS@108VAC
<b>OPERATION</b>	
Charging Indicator	Yellow LED
100% Charge Indicator	Green LED
Fault Indicator	Red LED
<b>PROTECTION</b>	
Output Reverse Polarity	Electronic Protection - Automatic Reset
Output Short Circuit	Electronic Protection - Automatic Reset
AC Overload	Current Limited
DC Overload	Current Limited
<b>MECHANICAL</b>	
Operating Temperature	-22°F to +122°F (-30°C to +50°C)
Housing	Shock and Water Resistant Aluminum

## Battery Charger Maintenance

### **WARNING**

**USE CHARGER ONLY ON BATTERY SYSTEMS WITH AN ALGORITHM SELECTED THAT IS APPROPRIATE TO THE SPECIFIC BATTERY TYPE. OTHER USAGE MAY CAUSE PERSONAL INJURY AND DAMAGE.**

**LEAD ACID BATTERIES MAY GENERATE EXPLOSIVE HYDROGEN GAS DURING NORMAL OPERATION. KEEP SPARKS, FLAMES, AND SMOKING MATERIALS AWAY FROM BATTERIES. PROVIDE ADEQUATE VENTILATION DURING CHARGING. NEVER CHARGE A FROZEN BATTERY.**

**STUDY ALL BATTERY MANUFACTURERS' SPECIFIC PRECAUTIONS SUCH AS RECOMMENDED RATES OF CHARGE AND REMOVING OR NOT REMOVING CELL CAPS WHILE CHARGING.**

### **DANGER**

**RISK OF ELECTRIC SHOCK. CONNECT CHARGER POWER CORD TO AN OUTLET THAT HAS BEEN PROPERLY INSTALLED AND GROUNDED IN ACCORDANCE WITH ALL LOCAL CODES AND ORDINANCES. A GROUNDED OUTLET IS REQUIRED TO REDUCE RISK OF ELECTRIC SHOCK - DO NOT USE GROUND ADAPTERS OR MODIFY PLUG. DO NOT TOUCH UNINSULATED PORTION OF OUTPUT CONNECTOR OR UNINSULATED BATTERY TERMINAL. DISCONNECT THE AC SUPPLY BEFORE MAKING OR BREAKING THE CONNECTIONS TO THE BATTERY WHILE CHARGING. DO NOT OPEN OR DISASSEMBLE CHARGER. DO NOT OPERATE CHARGER IF THE AC SUPPLY CORD IS DAMAGED OR IF THE CHARGER HAS RECEIVED A SHARP BLOW, BEEN DROPPED, OR OTHERWISE DAMAGED IN ANY WAY - REFER ALL REPAIR WORK TO QUALIFIED PERSONNEL. NOT FOR USE BY CHILDREN.**

1. For flooded lead-acid batteries, regularly check water levels of each battery cell after charging and add distilled water as required to level specified by battery manufacturer. Follow the safety instructions recommended by the battery manufacturer.
2. Make sure charger connections to battery terminals are tight and clean.
3. Do not expose charger to oil or to direct heavy water spraying when cleaning vehicle.



## Battery Charger Troubleshooting

### No Lights at all

No Lights at all indicate that AC power to the charger is not connected or that the AC voltage is too low. It could also indicate an internal failure in the charger.

1. Check the connections to AC power. Check for AC voltage between 90 and 260 VAC at the charger.
2. If the AC voltage is verified to be correct at the connection to the charger, and the charger still displays no lights at all, return the charger for service.

### FAULT LED Flashing

The Fault LED flashes to indicate the micro-controller inside the battery charger has detected a fault. The fault detected is indicated by the number of flashes. Count the number of flashes to determine the fault.

With any battery system, the most common problem will be a faulty battery connection. Because of the high likelihood of a battery connection problem, it is always worthwhile to confirm that all connections are good before checking for any other problems.

#### [1 Flash] - High Battery Voltage

1. Indicates a high battery voltage. Check that the battery charger voltage is consistent with the battery pack voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports.
2. Check for wiring errors.
3. This fault will automatically clear and the charger will restart charging when this problem is removed.
4. High battery voltage could also occur if there is another source charging the battery. Disconnect any other sources during charging.
5. If this problem does not clear after the battery voltage is confirmed to be less than 2.4V per cell, return the charger for service.

#### [2 Flashes] - Low Battery Voltage

1. Indicates either a battery failure, no battery connected, or a lower than expected battery voltage. Check the battery and battery connections.
2. Check the nominal battery voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports. Confirm that a nominal battery voltage is the same as the charger voltage.
3. This fault will clear automatically when the low battery voltage problem is rectified.

4. If this problem does not clear after the battery voltage is confirmed to be higher than 1.0V per cell and all connections are good, return the charger for service.

#### [3 Flashes] - Charge Time-out

Indicates the battery failed to charge within the allowed time. This could occur if the battery is of larger capacity than the algorithm is intended for. In unusual cases it could mean charger output is reduced due to high ambient temperature. It can also occur if the battery is damaged, old, or in poor condition.

1. Check the battery for damage such as shorted cells and insufficient water. Try the charger on a good battery.
2. If the same fault occurs on a good battery, check the connections on the battery and connection to AC, and the AC voltage itself.
3. Confirm that the nominal battery pack voltage is the same as the battery charger voltage.
4. This fault must be cleared manually by unplugging the AC, waiting 30 seconds and reconnecting the AC power.
5. If a charger displays this fault on a battery pack, and the pack is of questionable status, reset the charger by disconnecting AC for 30 seconds, and then reconnect the AC to start a new charge cycle. After a few charge cycles, this problem could stop occurring as the pack "recovers."

#### [4 Flashes] - Check Battery

This fault indicates the battery pack could not be trickle charged up to the minimum level required for the normal charge cycle to be started.

1. Check that none of the battery pack connections between modules are reversed or incorrectly connected.
2. Check that one or more cells in the battery are not shorted.
3. Confirm that the nominal battery pack voltage is the same as the battery charger voltage.
4. Try the charger on a good battery.
5. If this fault occurs, the battery is likely in poor condition. Try to recover the pack with a charger that can charge the individual cells - such as an automotive charger. Be sure to set this charger to the appropriate voltage - 6V per 6V battery, 12V per 12V string/battery.

## SECTION 3 - CHASSIS & SCISSOR ARMS

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### *[5 Flashes] - Over Temperature*

This fault indicates the charger has become too hot during operation. Though not damaging to the charger, charge time will be extended significantly.

1. This fault indication will not clear automatically, but the charger will restart charging automatically when the temperature drops. The fault indication must be cleared manually by unplugging the AC, waiting 30 seconds and reconnecting the AC power.
2. If possible, move the machine to a cooler location.
3. Confirm that dirt or mud is not blocking the cooling fins of the charger. Clean the charger. Rinse the charger with a low pressure hose if required. Do not use high pressure. Do not use a pressure washer.

### *[6 Flashes] - Over Load/Over Temperature*

This fault indicates that the batteries will not accept charge current, or an internal fault has been detected in the charger. This fault will nearly always be set within the first 30 seconds of operation. If it occurs after the charger has started charging normally, be sure to make a note of it.

1. Remove excessive AC loads from inverter if installed.
2. Try to clear the fault by unplugging the AC, waiting 30 seconds and reconnecting the ac power.
3. Check all battery connections. Look for a high resistance connection. The most likely reason for this fault is a fault in the battery such as a bad battery connection, an open cell, or insufficient water.
4. This fault will occur if an internal fuse inside the charger blows. If the green wire is shorted to ground even momentarily, this fuse will blow. To check the fuse, measure with an ohmmeter between the green and red wires with the AC disconnected. If a short circuit is not measured, the fuse has blown. Return unit to a service depot to have this fuse replaced.
5. If this fault occurs after battery charging has started, confirm that AC power was not interrupted and that all battery connections are good.
6. If all battery connections are good, an internal fault has been detected and the charger must be brought to a qualified service depot.

### **Excessive Battery Watering Requirements or Strong Sulphur (Rotten Egg) Smell**

These symptoms indicate over-charging or high battery temperature. These symptoms are unlikely to be caused by too high a charge current since the maximum charge current of the charger will be small compared to even a moderately sized battery pack. The most likely cause for this problem is incorrect charge algorithm setting and/or high ambient temperatures.

1. Confirm that the battery pack is not too small - usually > 50Ah.
2. Confirm that the nominal battery voltage matches the charger output voltage.
3. Confirm the correct battery charge algorithm. If the battery pack is new, the algorithm will need to be changed if the pack is not the same as the old one. For instructions on how to determine and change the battery charge algorithm see the following sub-section.
4. If the output voltage of the charger seems excessive, return the charger for service. Contact JLG to get the expected battery voltage settings for the charger in question. Be sure to have the charger's serial number and charge algorithm setting available when calling.

**Checking/Changing the Battery Charge Algorithm**

The charger is pre-loaded with programming algorithms for the specific batteries detailed in Table 3-4, Battery Algorithms. Contact JLG if your specific battery model is not listed.

Each time AC power is applied with the battery pack not connected, the charger enters an algorithm select/display mode for approximately 11 seconds. During this time, the current Algorithm # is indicated on the Yellow Charging LED. A single digit Algorithm # is indicated by the number of blinks separated by a pause. A two digit Algorithm # is indicated by the number of blinks for the first digit followed by a short pause, then the number of blinks for the second digit followed by a longer pause.

To check/change the charging algorithm:

1. Disconnect the charger positive connector from the battery pack. Apply AC power and after the LED test, the Algorithm # will display for 11 seconds.
2. To change the algorithm, touch the connector to the battery's positive terminal for 3 seconds during the 11 second display period and then remove. The Algorithm # will advance after 3 seconds. Repeat this procedure until the desired Algorithm # is displayed. A 30 second time-out is extended for every increment. Incrementing beyond the last Algorithm will recycle back to the first Algorithm. When the desired Algorithm is displayed, touch the charger connector to the battery positive terminal until the output relay makes a clicking noise (approx. 10 seconds). The algorithm is now in the permanent memory.

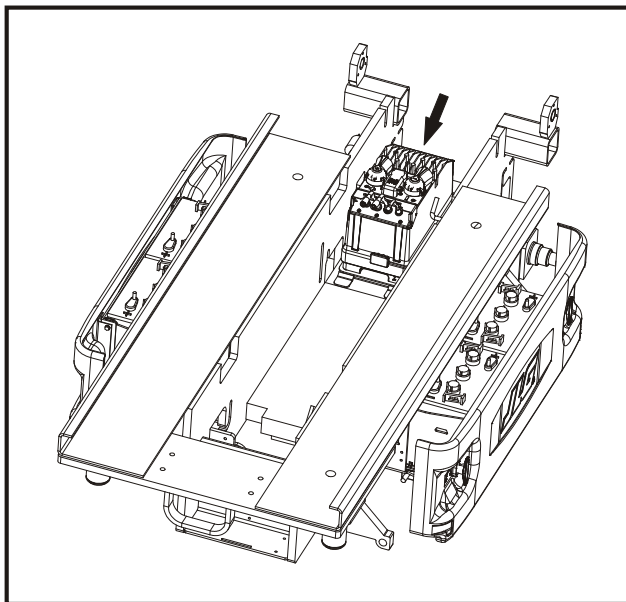
3. Remove the AC power from the charger and reconnect the charger's positive connector to the battery. It is recommended to check a newly changed algorithm by repeating the above steps 1 and 3.

**Table 3-4. Battery Algorithms**

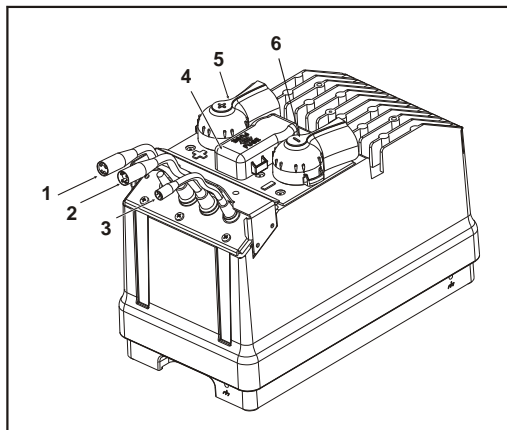
Algorithm #	Battery Type
43	Harris Battery Discover EVGC6A-A (AGM)
35	JLGP/N 0400242
23	Douglas Flooded (JLG default) GES Battery A1055 Trojan T105 East Penn GC-110-WNL Trojan T105 PLUS Champion CHGC2 GC2 US BATT EV-145-WNL US BATT 2200 XC
8	Concorde 10xAh AGM
7	J305 DV/DT CP
6	DEKA 8G31 Gel
5	Trojan 30/31XHS
4	US Battery USB2200
3	T105 DV/DT CP
2	Trojan T105 tapped
1	Trojan T105

**3.12 BATTERY CHARGER/INVERTER (OPTION)**

The Battery Charger/Inverter is located on the top of the chassis at the rear of the machine. Raise and secure scissor arms with arm prop to gain access to the charger.



**Figure 3-37. Battery Charger/Inverter Location**



- 1. AC Output Connector
- 2. AC Input Connector
- 3. Remote On/Off Switch Cable
- 4. External DC Fuse Location
- 5. DC (+) Connection
- 6. DC (-) Connection

**Figure 3-38. Battery Charger/Inverter**

**Table 3-5. Battery Charger/Inverter Specs**

Battery Charger/ AC Inverter	Specification
<b>AC Inverter - Specs</b>	
Output Power (Continuous)	1000 W
Output Power (Surge)	3000 W
AC Output Current	36 A
AC Output Voltage	115 to 125 VAC
Output Frequency	60 Hz
DC Input Voltage	21.2 to 29 VDC
Remote ON/OFF	Yes
<b>Charger - Specs</b>	
Nominal DC Output Voltage	28 VDC
Maximum DC Output Voltage	33 VDC
Maximum DC Output Current	23 to 27 ADC
Required Interlock Current	1 A
Input Voltage (AC)	100 to 130 VAC
Nominal Input Voltage (AC)	120 VAC
Input Frequency	54 to 66 Hz
<b>Operation</b>	
Charging Indicator	Yellow LED
100% Charge Indicator	Green LED
Fault Indicator	Red LED
<b>Protection</b>	
Output Reverse DC Polarity	125 A Replaceable Fuse
Output AC Short Circuit	Electronic Protection - Automatic Reset
AC Overload	20 A Internal Slow Blow Charger Fuse
DC Overload	Voltage Limited - Internally Controlled
<b>Mechanical</b>	
Operating Temperature	-40°F to +185°F (-40°C to +85°C)
Housing	Shock and Water Resistant Aluminum

## Battery Charger/Inverter Troubleshooting

The Fault LED Flash Codes are the same as the Battery Charger (see Battery Charger Troubleshooting on pages 3-29 and 3-30).

For further specification and troubleshooting information refer to the manufacturers' Charger/Inverter Owner's Guide shipped with the machine. Publication - RM1024-JLG - Part # 3128406.

Use the information below to supplement the information in the Inverter/Charger manual. First, go through the troubleshooting in the Owner's Guide (JLG part number 3128406), then use the procedures below. For control of the Inverter/Charger there is an 8 position connector on a cable entering the case of the Inverter/Charger. Looking at the pins of the connector, terminals are numbered clockwise starting with number 1 nearest the notch. Terminal 8 is in the center.

### No charge voltage:

1. Disconnect control cable from Inverter/charger.
2. Turn on machine.
3. Inverter/charger control cable 8 position connector socket 1 should have Vbatt present. If it is not, check charger interlock connector, 2 position, socket 1. If voltage is present there replace the Inverter/Charger data interface harness. If Vbatt is not present at the 2 position connector socket 1, check the circuit through the chassis harness back to Ground Module terminal J1-19.

### Loads will not start when there is no external AC/ Inverter will not produce AC power:

1. Check that Inverter/Charger switch is in ON position.
2. Disconnect control cable from the Inverter/Charger.
3. Turn on machine.
4. Inverter/Charger control cable socket 2 should have Vbatt present when the switch is ON. If not check that there is Vbatt on the switch Yellow/Red wire. Vbatt signal originates from Ground module pin J1-19 then goes to harness Interlock connector terminal 1 (Yellow/Red wire), then to switch.

### LED(s) suspected to be bad:

1. Disconnect Inverter/Charger control cable from the charger (8 position connector) and the 6 position connector at the chassis harness. There should be continuity between the following:
  - a. 8 pos. terminal 3 to 6 pos. terminal 3
  - b. 8 pos. terminal 4 to 6 pos. terminal 5
  - c. 8 pos. terminal 5 to 6 pos. terminal 4
  - d. 8 pos. terminal 6 to 6 pos. terminal 6

2. Disconnect Inverter/Charger control cable at the 6 position connector and the chassis harness at the 4 position connector at the Ground Box. There should be continuity between the following:
  - a. 6 pos. terminal 3 to 4 pos. terminal 1
  - b. 6 pos. terminal 4 to 4 pos. terminal 3
  - c. 6 pos. terminal 5 to 4 pos. terminal 2
  - d. 6 pos. terminal 6 to 4 pos. terminal 4
3. If wiring is found to be good, the LED printed circuit card is likely to be bad.

### Interlock Cable suspected to be bad or vehicle thinks charging is in progress, but it is not:

1. Disconnect Interlock (2 position) connector on the Inverter/Charger control cable.
2. Turn on machine.
3. There should be Vbatt present on the Interlock connector socket 1.
4. Turn off machine.
5. Disconnect Inverter/Charger control cable at the charger.
6. Inverter/Charger connector (8 position) pin 6 should have continuity to Interlock connector pin 2 and then to ground module socket J1-29.

### Ground Module powered while key is off or similar behavior:

This condition can be caused by various ground module outputs getting shorted to battery. If not done already, cycle power and check for fault codes. If no fault codes, perform the following:

1. Disconnect the Inverter/Charger control cable at the 8 position connector and the 2 position Interlock connector.
2. Set digital multimeter to diode check or continuity check to check diode in Inverter/Charger control harness. If the meter does not have these features a low range Ohm scale (20 Ohms for example) will work.
3. Place red lead on 8 position connector pin 1. Place black lead on Interlock connector pin 1.
4. Meter should read an open. Swap leads. Meter should read a short. If either condition is not good, replace Inverter/Charger control cable.

## SECTION 3 - CHASSIS & SCISSOR ARMS

### 3.13 DRIVE MOTOR CABLE ROUTING

USA Built Machines Prior to S/N 0200170585 &  
Belgium Built Machines Prior to S/N 1200015159:

#### **⚠ CAUTION**

BE SURE TO PULL THE BATTERY DISCONNECT ANYTIME WORK IS BEING PERFORMED ON THE DRIVE MOTORS OR DRIVE MOTOR CABLING.

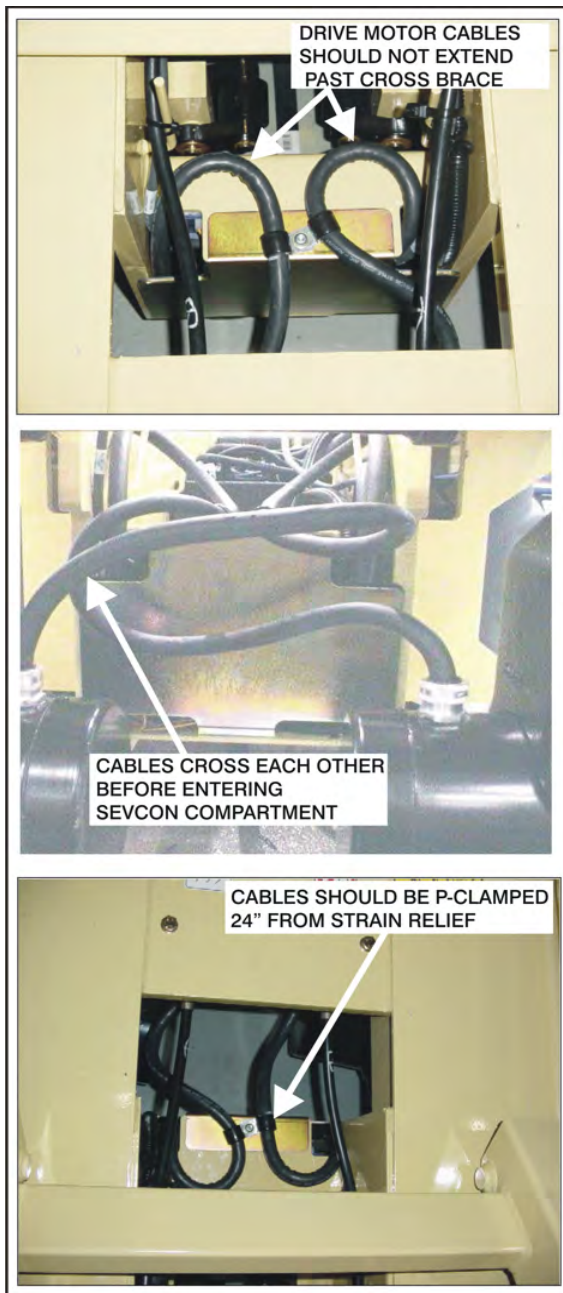


Figure 3-39. Motor Cable Routing (1930ES)

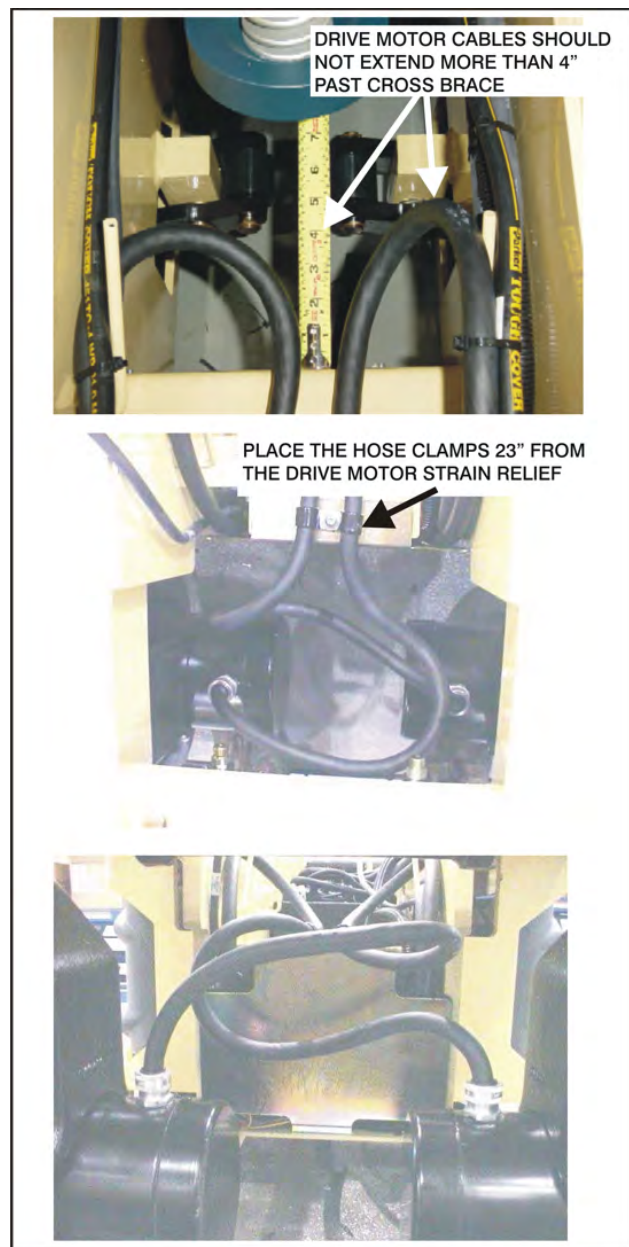


Figure 3-40. Motor Cable Routing (2030ES/2030ES/2030ES)

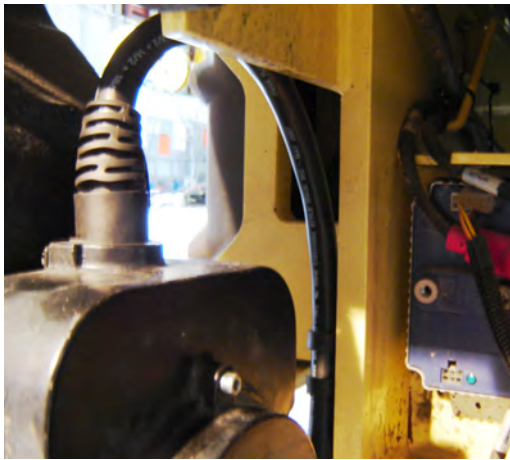
**USA Built Machines S/N 0200170585 to Present & Belgium Built Machines S/N 1200015159 to Present:**

**NOTE:** The below procedures (1 - 19) apply to 1930ES only.

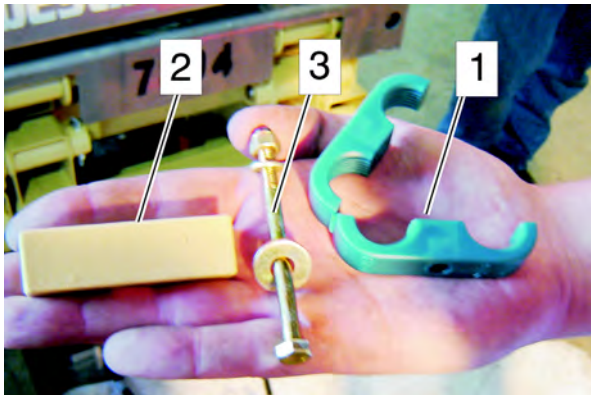
**⚠ CAUTION**

**BE SURE TO PULL THE BATTERY DISCONNECT ANYTIME WORK IS BEING PERFORMED ON THE DRIVE MOTORS OR DRIVE MOTOR CABLING.**

1. Orient the drive cables going back towards the rear of the machine as shown below.

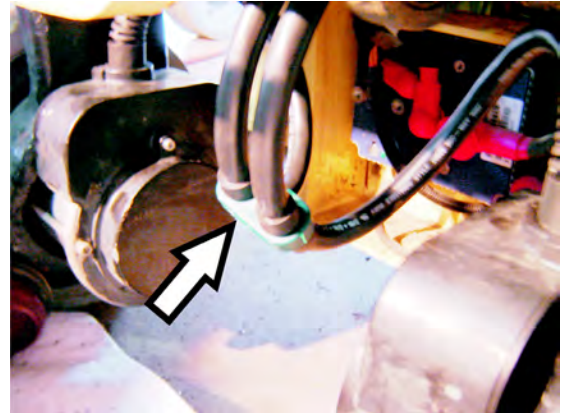


2. Loop the cables forward towards the front of the machine then up and back so that the clamping rings on the cables are aligned together.
3. Obtain the Cable Clamp and hardware.

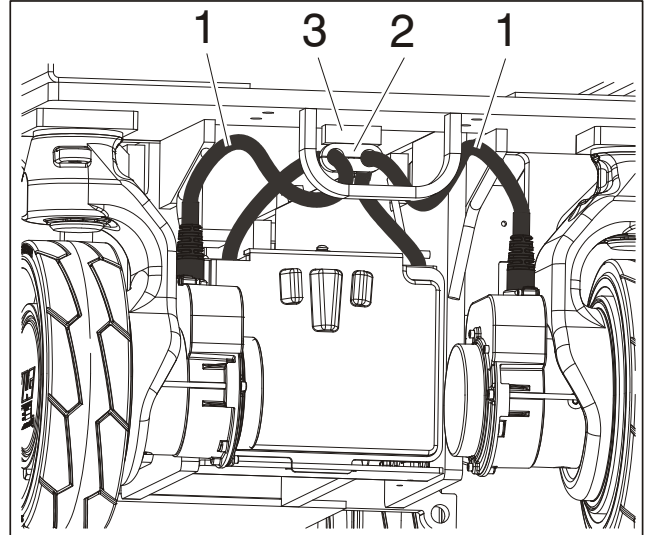


- |                 |                               |
|-----------------|-------------------------------|
| 1. Cable Clamp  | 3. Capscrew, Washers, and Nut |
| 2. Spacer Plate |                               |

15. Place the Green Clamp on the clamping rings as shown below.



16. Bolt the clamp onto the underside of the frame.
  - a. The Spacer goes between the frame and the Clamp.
  - b. Place the Larger Washer against the clamp.
17. Connect the drive motor cables to the power module.
18. Tuck all wires into the power module compartment and install cover.



1. Drive Cables
2. Cable Clamp
3. Spacer Plate

19. Reconnect battery cable plug. Power up machine and operate the drive function to ensure drive motors operate properly.

## SECTION 3 - CHASSIS & SCISSOR ARMS

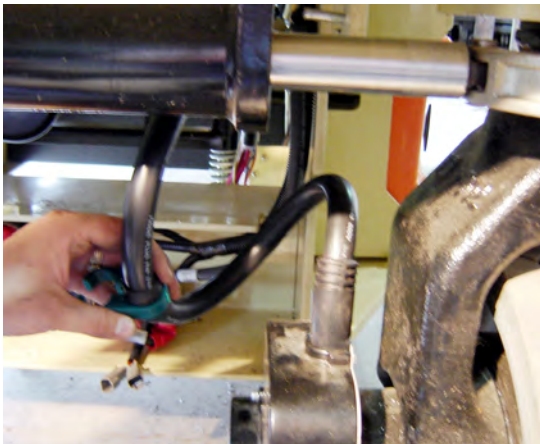
**USA Built Machines S/N 0200170585 to Present & Belgium Built Machines S/N 1200015159 to Present:**

**NOTE:** The below procedures apply to 2030ES/2630ES/2646ES/3246ES only.

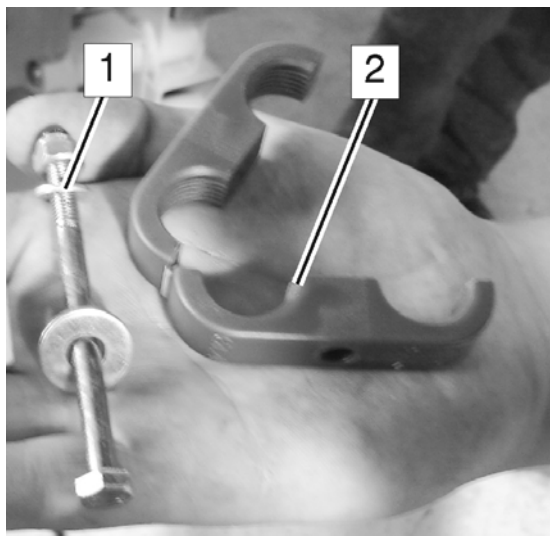
### **⚠ CAUTION**

**BE SURE TO PULL THE BATTERY DISCONNECT ANYTIME WORK IS BEING PERFORMED ON THE DRIVE MOTORS OR DRIVE MOTOR CABLING.**

1. Orient the drive cables going back towards the rear of the machine. Loop the cables forward towards the front of the machine then up and back. Place the Green Clamp on the clamping ring as shown below.

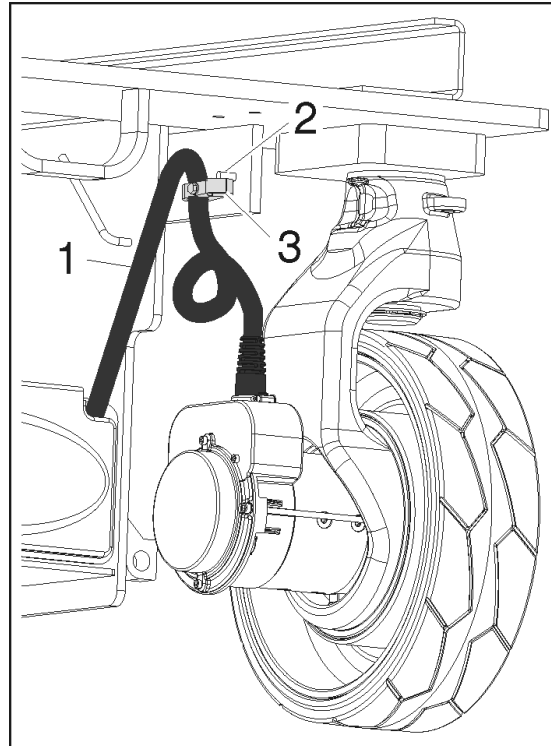


2. Obtain the Cable Clamp and hardware.



1. Bolt, Washers, and Nut
2. Cable Clamp

3. Bolt the Green Clamp onto the backside of the frame using the the back hole drilled in step #4. The roll pins inserted in the front-most holes act as a stop to prevent the clamp from turning.

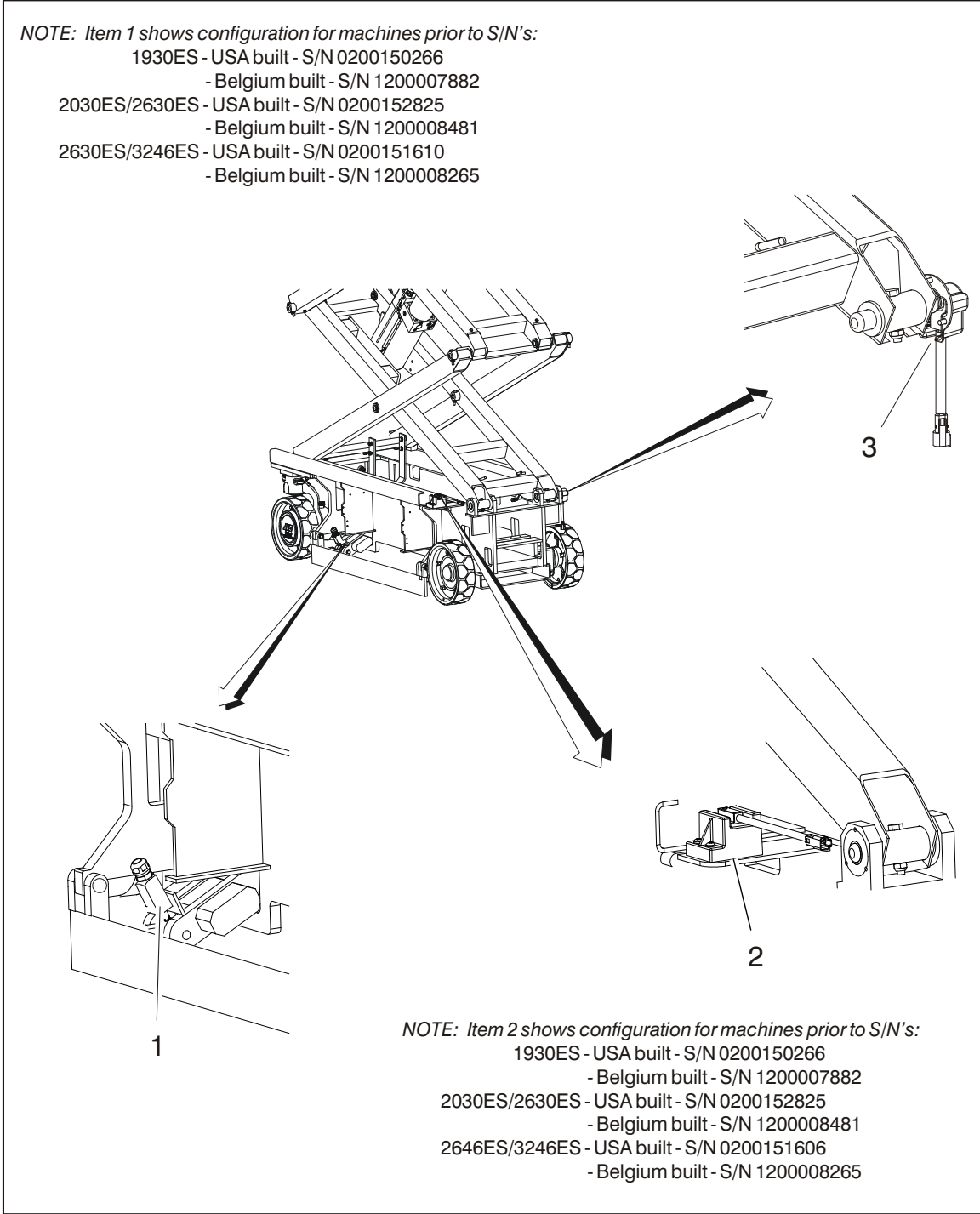


1. Drive Cable
2. Roll Pin
3. Cable Clamp

**NOTE:** When bolting the green clamp onto the frame, place the larger washer against the clamp on the outside of the clamp.

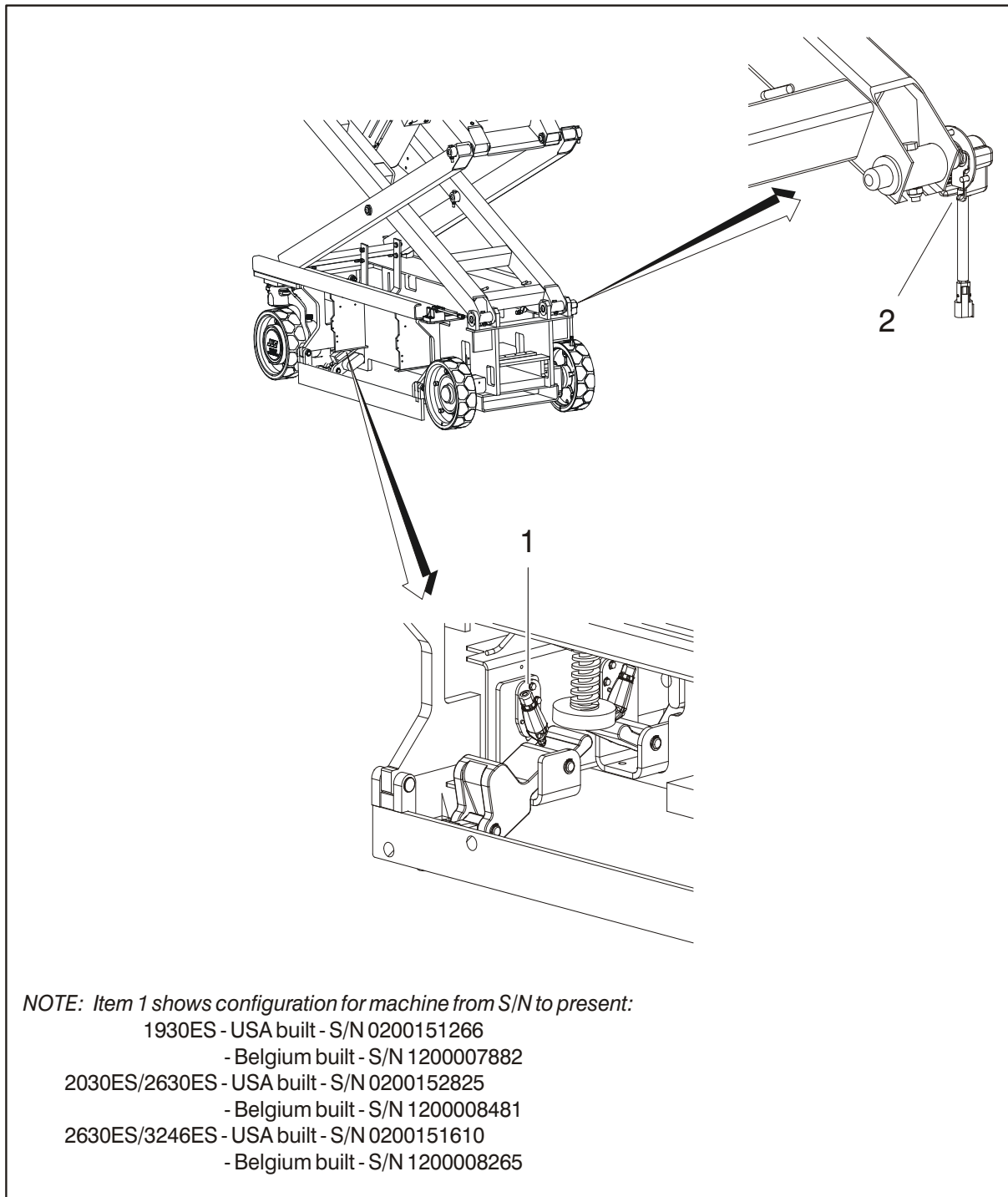
4. Connect the drive motor cables to the power module..
5. Tuck all wires into the power module compartment and install cover.
6. Reconnect battery cable plug. Power up machine and operate the drive function to ensure drive motors operate properly.





1. Pothole Switch (Typical on opposite side of machine)
2. Proximity Switch
3. Rotary Angle Switch

**Figure 3-41. Limit Switch Locations - 1 of 2**



1. Pothole Switch (Typical on opposite side of machine)
2. Rotary Angle Switch

**Figure 3-42. Limit Switch Locations - 2 of 2**

3.14 POTHOLE SWITCH REPLACEMENT

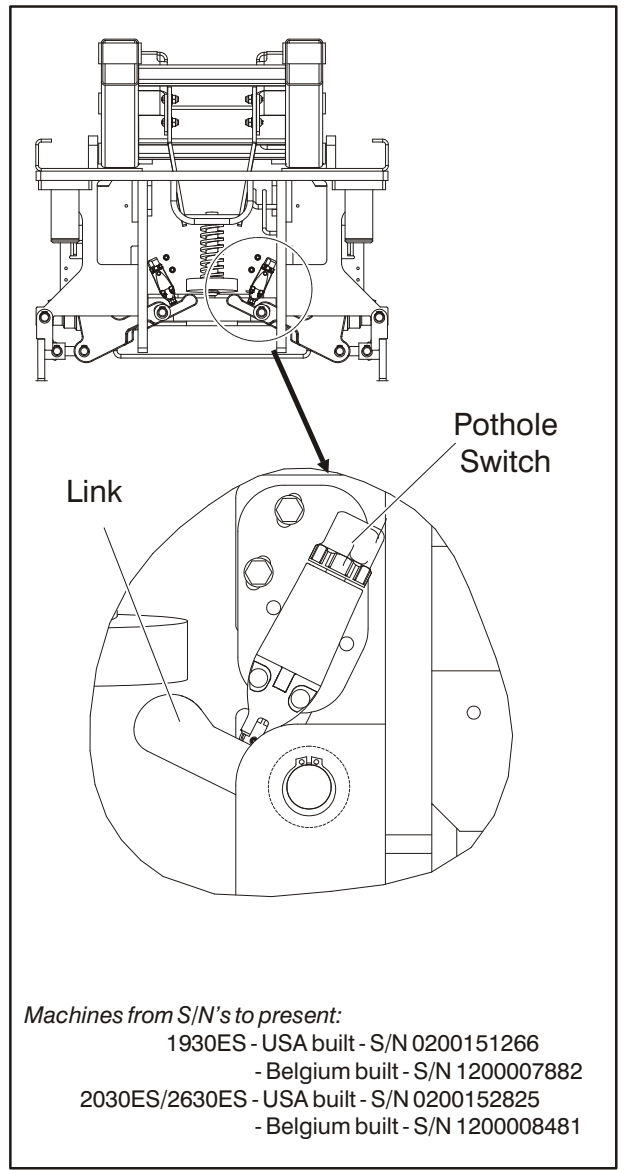
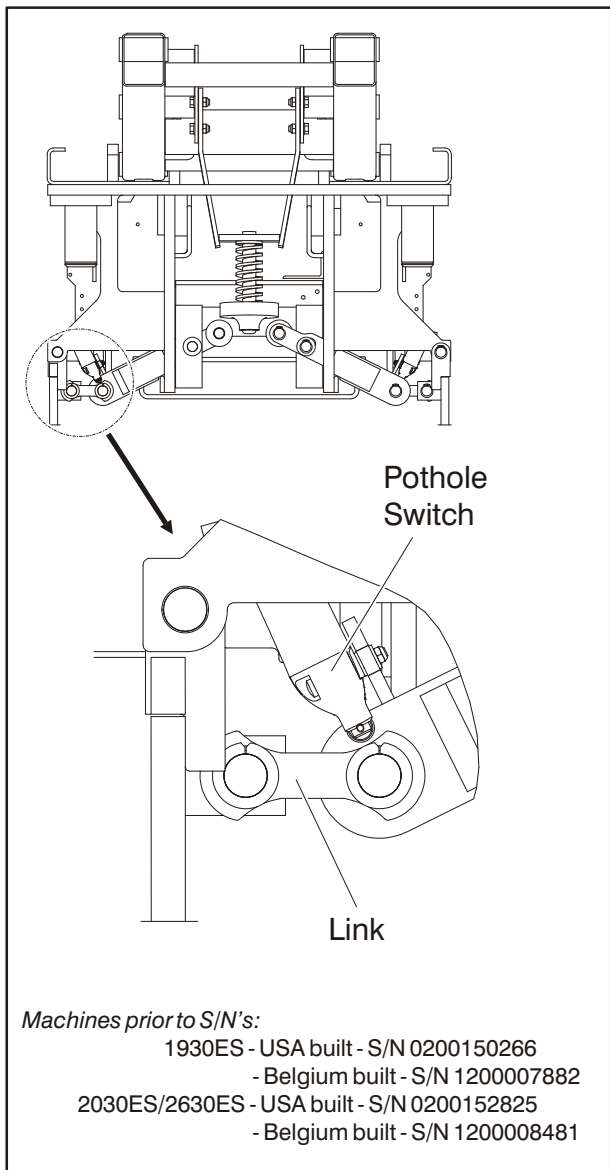
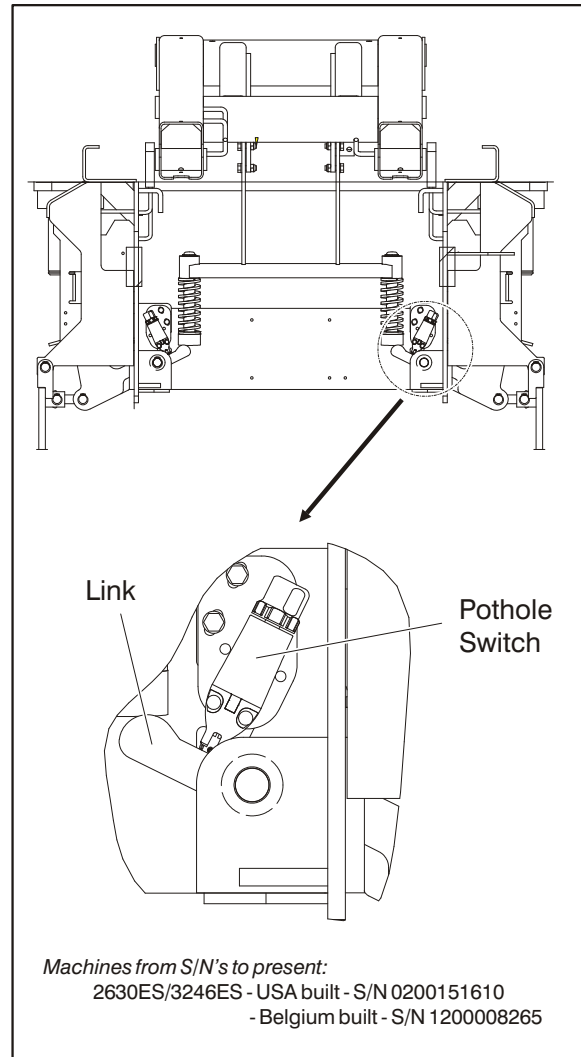
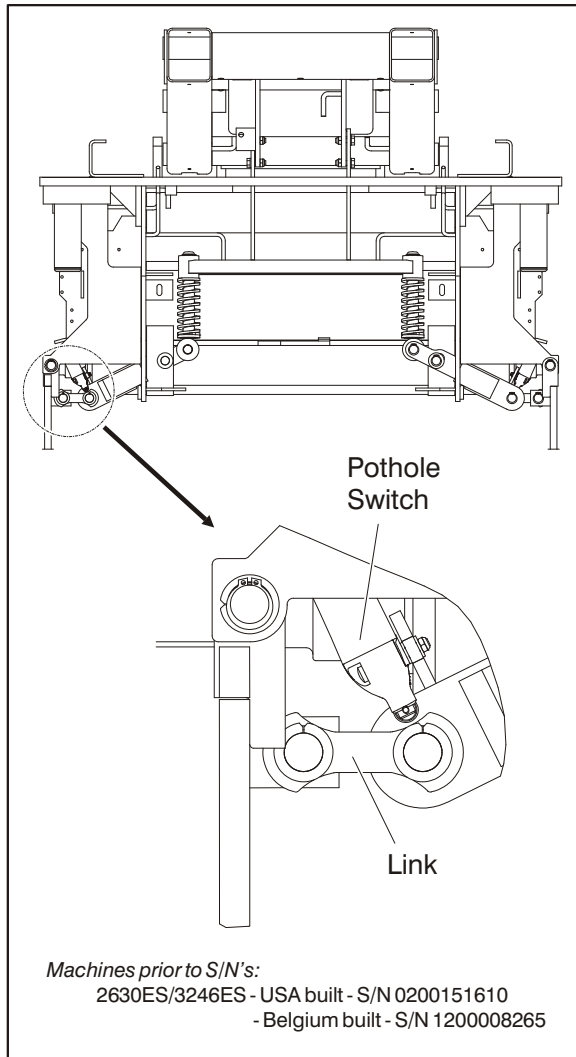


Figure 3-43. Pothole Switch Adjustment - 1930ES/2030ES/2630ES

1. With the machine in the stowed position and the battery door open, remove the old pothole switch.
2. Mount the new limit switch and harness to crank with the washer placed behind the switch.
3. Adjust the switch by inserting an 1/8" shim between the link and the switch plunger.
4. Push the switch to fully depress the plunger and tighten the switch screws.
5. Repeat this procedure on the opposite side.
6. Raise and lower the machine from the ground control several times to ensure that the switch is functioning properly.

**NOTE:** From the platform, raise and lower the machine and check that the switch is operating properly by cutting back to elevated speed when the pothole is deployed. Drive will be cutout if pothole is not set.

## SECTION 3 - CHASSIS & SCISSOR ARMS



**Figure 3-44. Pothole Switch Adjustment - 2630ES/3246ES**

1. With the machine in the stowed position, and the battery door open remove the old pothole switch.
2. Mount the new limit switch and harness to crank with the washer placed behind the switch.
3. Adjust the switch by inserting an 1/8" shim between the link and the switch plunger.
4. Push the switch to fully depress the plunger and tighten the switch screws.
5. Repeat this procedure on the opposite side.
6. Raise and lower the machine from the ground control several times to ensure that the switch is functioning properly.

**NOTE:** From the platform, raise and lower the machine and check that the switch is operating properly by cutting

*back to elevated speed when the pothole is deployed. Drive will be cutout if pothole is not set.*

### Pothole Switch Replacement (Service Kit - 1001109345)

**NOTE:** Omit step 1 following if switches are the outboard of frame rails design.

1. Mount the new switches to the new mounting plates using the supplied screws, nuts and washers. Tighten switch securely to the mounting plate. **Note there is a right side and left side mounting plate, the plate mounting holes will mount towards the center of the machine on both sides.**

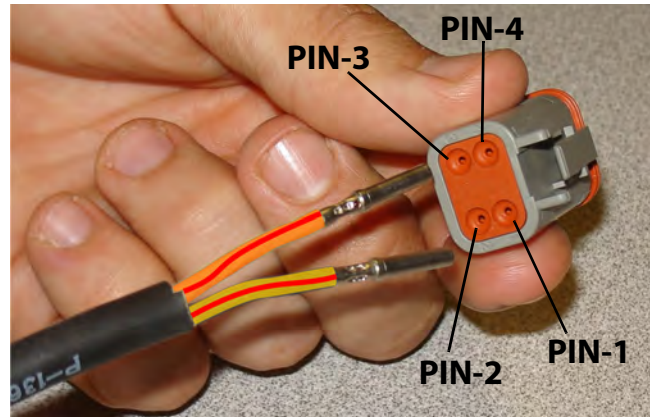


2. Strip approximately 1/4" of insulation off of the wires of the existing wire harness. Using a crimping tool install a new socket terminal onto each of the stripped ends of the existing wiring harness wires.



3. Remove the wedge lock (orange) from the front end of the new connector, then load the socket terminals into the back of the connector.

**NOTE:** Reference the chart below for proper pin loading.



4. With the socket terminals properly installed, re-insert the wedge lock (orange) back into the socket to lock the socket terminals in place.



	EXISTING SWITCH			NEW SWITCH
	TELEMECHANIQUE	HONEYWELL		TELEMECHANIQUE
IF EXISTING SWITCH IS WIRED TO PINS:	13 & 14	3 & 4	NEW CONNECTOR SHOULD BE LOADED TO PINS:	1 & 4
	21 & 22	1 & 2		2 & 3

## SECTION 3 - CHASSIS & SCISSOR ARMS

5. Before connecting the wire harness to the new switch/mount assembly, apply the supplied dielectric grease to both the connector end and the switch socket pin areas.

**NOTE:** There is a right side and left side mounting plate, the plate mounting holes will mount towards the center of the machine on both sides.



6. Mount the new switch assembly to the machine using the supplied (10mm) bolts, nuts and washers.



7. Adjust the switch assembly.

### SWITCHES INBOARD (SHOWN BELOW)

When pothole bar is in the deployed position, adjust the switch/bracket assembly down until the plunger "clicks". Tighten the switch/bracket mounting screws until secure.

### SWITCHES OUTBOARD

When pothole bar is in the deployed position, depress the plunger fully and release just past the "click". Tighten the switch mounting screws until secure.

**NOTE:** Do not push the switch body down in contact with the pothole crank link.



8. Repeat this procedure on the opposite side pothole switch.
9. Power up machine and operate lift and drive to ensure proper function.

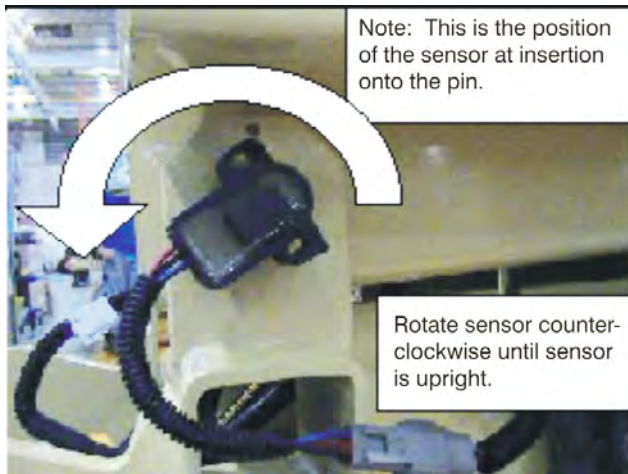
## Rotary Angle Sensor Replacement

### Removal:

1. Lower platform to the stowed position.
2. Disable the machine and disconnect the batteries.
3. Remove the screws securing the sensor cover to the frame and remove the sensor cover.
4. Disconnect the wiring harness from old/existing rotary angle sensor. Disconnect the sensor from the arm pin and remove the sensor.

### Installation:

1. Connect the wiring harness to the new rotary angle sensor.
2. Position and connect rotary angle sensor to the arm pin as shown below.



3. Rotate the sensor as described in the image above.

**NOTE:** The sensor is spring loaded. DO NOT rotate past its internal stops.

4. Install the rotary angle sensor cover and secure to the frame with the two screws.
5. Reconnect the batteries.

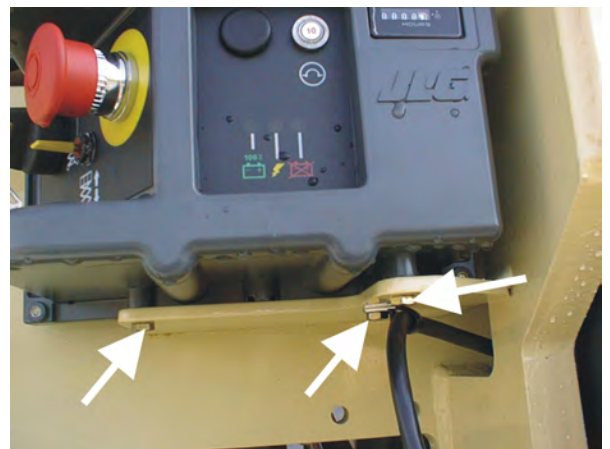
## 3.15 GROUND CONTROL STATION

**NOTE:** The Ground Control Station supplied with the ZAPI Power Module (production start mid-year 2010) does not require use of the printed circuit board inside the ground control box.

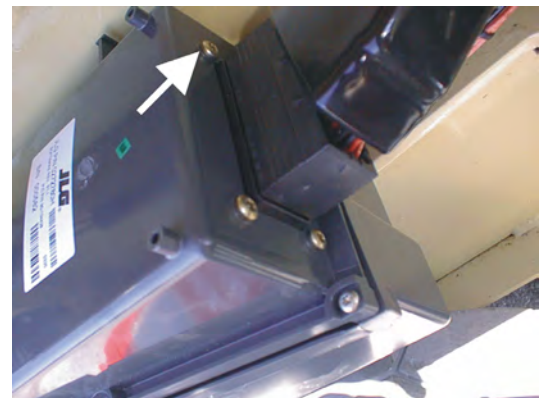
However box installation and removal instructions shown are exactly the same as the ground control box which does contain a printed circuit board and is used with previous machines supplied with the SEV-CON Power Module.

**NOTE:** Anytime the ground control box is removed, the tilt sensor must be re-calibrated. Refer to Section 5, JLG Control System to re calibrate the tilt.

## Printed Circuit Board (PCB) Replacement



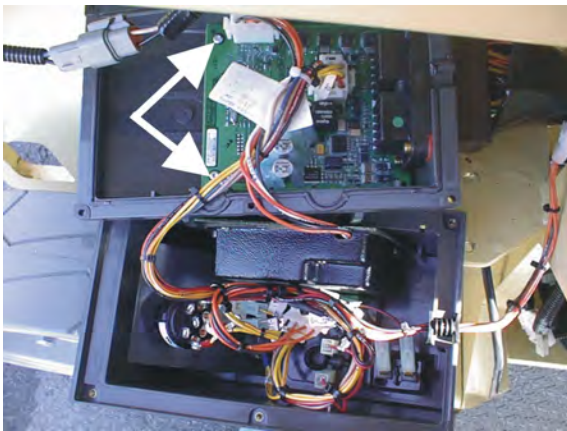
1. Disconnect the batteries.
2. Remove the three bolts at the bottom of the ground control station.



3. Remove the four bolts where the control cable enters into the control box.
4. Remove plug and place control box face down on a suitable work bench.



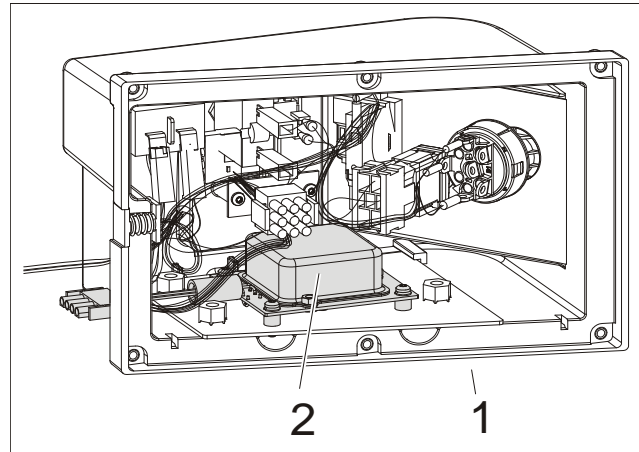
5. Remove the six bolts at the back of the ground control and separate.
6. Pull the pin connectors from the printed circuit board.



7. Remove the two bolts inside the control box that affix the printed circuit board to the control box.
8. Replace the printed circuit board and reassemble the ground control box.

### Tilt Sensor Replacement

Tilt Sensor, JLG P/N 4000006:



1. Ground Control Station
2. Tilt Sensor (JLG PN 4000006)

**Figure 3-45. Tilt Sensor Location**

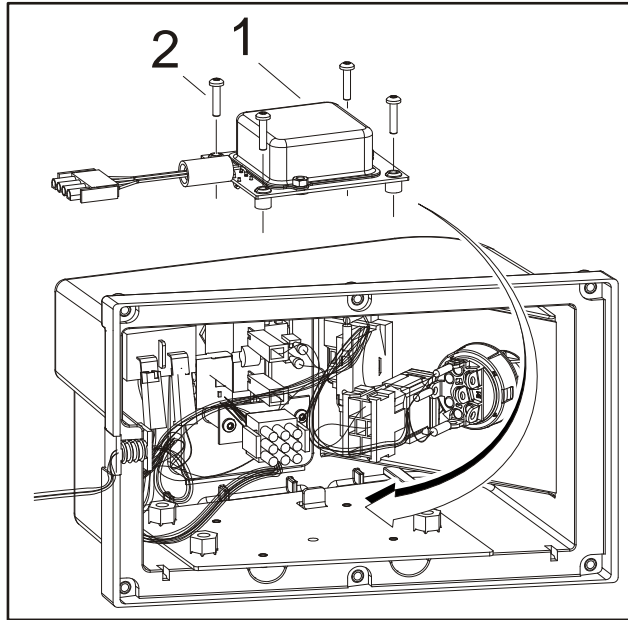
#### Tilt Sensor Removal:

**NOTE:** Refer to Figure 3-44., Tilt Sensor Removal for numbers in parenthesis.

1. Disconnect the batteries.
2. Open the Ground Control Station to gain access to the Tilt Sensor Assembly. (refer to prior mentioned procedures)
3. Remove the four Screws (2) to remove the Tilt Sensor (1) from the Ground Control Box.

**NOTE:** Follow the above procedures in reverse order when installing the tilt sensor assembly. After installing, be sure to calibrate the tilt sensor (refer to Section 5.2, Tilt Sensor Calibration).





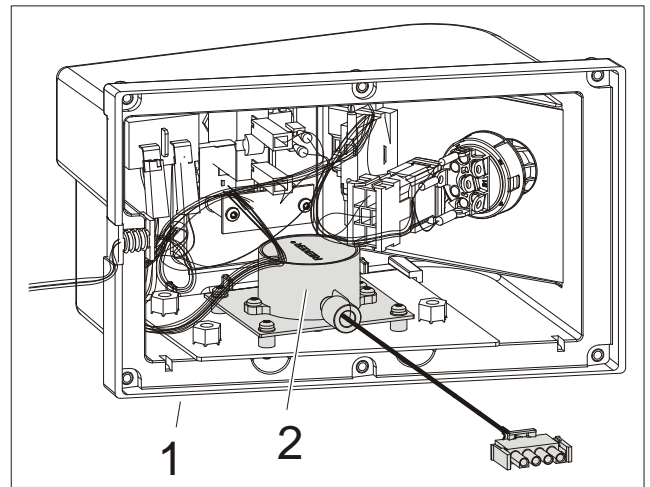
1. Tilt Sensor (JLG P/N 4000006)
2. Screw, 3.5 x 0.6 x 16 LG

**Figure 3-44. Tilt Sensor Removal**

**Table 3-6. Tilt Sensor Harness Chart**

Wire Color	Function	Connector Pin
Red	VCC	1
Black	Ground	4
Blue	PWMX	2
Yellow	PWMY	3

**Tilt Sensor, JLG P/N 4000021 and 100114936:**



1. Ground Control Station
2. Tilt Sensor (JLG P/N 4000021 or 100114936)

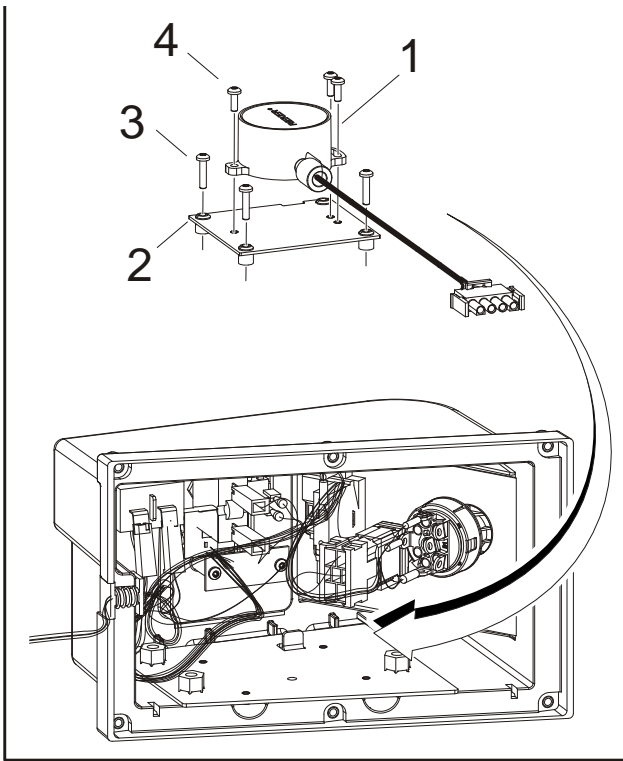
**Figure 3-45. Tilt Sensor Location**

**Tilt Sensor Removal:**

**NOTE:** Refer to Figure 3-46., Tilt Sensor Removal for numbers in parenthesis.

1. Disconnect the batteries.
2. Open the Ground Control Station to gain access to the Tilt Sensor Assembly. (refer to prior mentioned procedures)
3. Remove the four Screws (3), to remove the Tilt Sensor (1) and Sensor Mount (2) from the Ground Control Box.
4. The Tilt Sensor (1) can be removed from the Sensor Mount (2) by removing the three Screws (4).

**NOTE:** Follow the above procedures in reverse order when installing the tilt sensor assembly. After installing, be sure to calibrate the tilt sensor (refer to Section 5.2, Tilt Sensor Calibration).



1. Tilt Sensor (JLG P/N 4000021 or 1001114936)
2. Sensor Mount
3. Screw, 3.5 x 0.6 x 16 LG
4. Screw, 3.5 x 0.6 x 10 LG

**Figure 3-46. Tilt Sensor Removal**

**Table 3-7. Tilt Sensor Harness for 4000021**

Wire Color	Function	Connector Pin
Red	VCC	1
Green	PWMX	2
White	PWMY	3
Black	Ground	4

**Table 3-8. Tilt Sensor Harness for 1001114936**

Wire Color	Function	Connector Pin
Red	VCC	1
White	CANH	2
Green	CANL	3
Black	Ground	4

### 3.16 ARMS AND PLATFORM POSITIONING AND SUPPORT

**⚠ CAUTION**

**PLATFORM IS HEAVY AND PRESENTS A CRUSHING HAZARD. TAKE GREAT CARE WHEN REMOVING PLATFORM OR SCISSOR ARM ASSEMBLY**

The arm stack can be supported by using an overhead crane,(See Figure 3-47.). If an overhead crane is not available the stack may also be lifted by using a fork-truck using the following instructions:

1. With the forks on the forktruck slid close together, enter from the front of the machine and place the forks on the cross tube of the second arm weldment below the platform.
2. Slowly lift the arm stack with the forktruck while the manual descent valve is being engaged (this allows the oil to drain back into the tank).
3. Place machine on safety prop and leave the fork-truck in place.
4. At this point the lift cylinder removal may begin. (Refer to Section 4.6, Lift Cylinder Removal)

If removal of the platform becomes necessary use the above procedure to stabilize the platform for pin and platform removal.

**3.17 PLATFORM REMOVAL**

1. Support the platform using an overhead crane with straps capable of lifting at least 250 lbs (114 kg) (See Figure 3-47.). Refer to Section 3.16, Arms and Platform Positioning and Support.
2. Disconnect the battery plug at the chassis. Disconnect platform cable and foot switch cable, if applicable, from railing. Route the cables out through the hole at the rear of the platform to free platform of any constraints. If platform is equipped with an outlet plug, disconnect and route cable out of platform.
3. Remove the bolts attaching the pins and slide blocks at each corner to the arm stack. Carefully remove the four pins attaching the platform to the arm stack.
4. Lift the platform from the armstack and set aside.

**NOTE:** When attaching platform back onto scissor arm assembly, follow removal procedures in reverse order.

**NOTICE**

**FOR MACHINES EQUIPPED WITH LOAD SENSING SYSTEM (LSS), ENSURE ARROWS ON THE LSS PIN ARE POINTING DOWN BEFORE INSERTING BOLTS INTO PIN. NOT APPLICABLE FOR MACHINES WITHOUT LSS.**



**3.18 SCISSOR ARMS REMOVAL**

1. Remove platform (refer to Section 3.17, Platform Removal).
2. Disconnect all wiring and cables attached to scissor arm assembly.
3. Remove lift cylinder (refer to Section 4.6, Lift Cylinder Removal).
4. The scissor arms can be removed as a complete unit or individually.

Removing scissor arm assembly as a complete unit:

1. Remove the pin attaching the bottom scissor arms to the rear of the frame by removing the bolt.
2. Place two straps around each end of the the entire scissor arm assembly. Using an overhead crane, slowly and carefully move the arm stack forwards so that slide blocks at front of machine slide out the front of the slide channel on the frame.

**NOTE:** Overhead crane and straps must be capable of lifting at least 1545 lbs (701 kg).

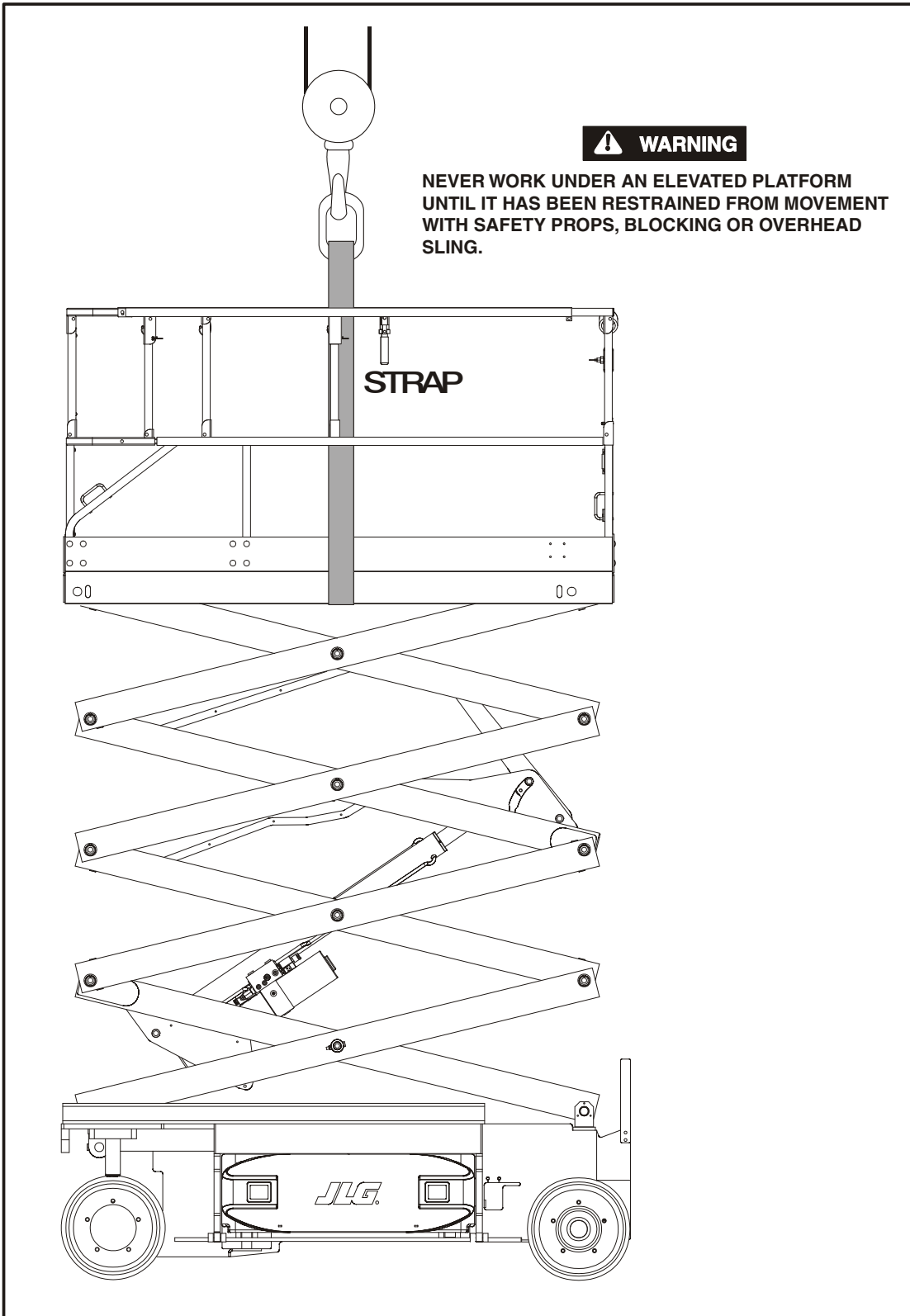
3. Once slide blocks are clear of machine, the scissor stack can be moved to a more desirable location for further arm disassembly.

Removing scissor arms individually:

1. Start with the top arms (closest to platform).
2. Secure each arm section being removed using an overhead crane with suitable lifting straps.
3. Remove the bolts securing the connecting pins in place.
4. Remove the pins from the arms.
5. Remove the arm section from the machine using the overhead crane.
6. Repeat previous steps for remaining arm sections.

**NOTE:** When attaching scissor arm assembly back onto frame, follow removal procedures in reverse order.

Self locking fasteners, such as nylon insert and thread deforming locknuts, are not intended to be reinstalled after removal. Always use new replacement hardware when installing locking fasteners.



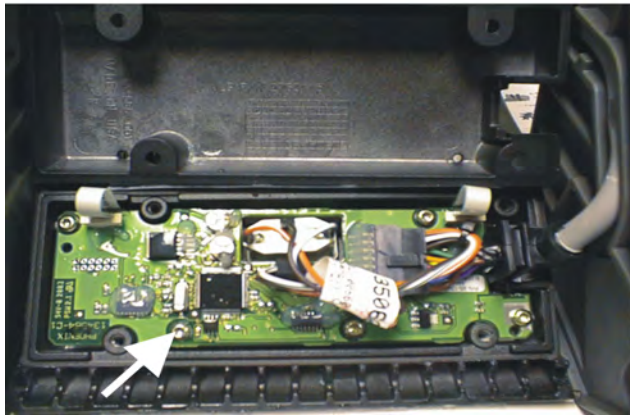
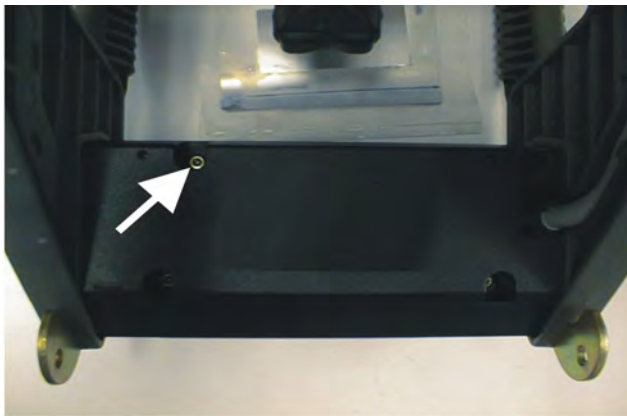
**Figure 3-47. Arms and Platform Positioning and Support**

**3.19 PLATFORM CONTROL STATION**

1. Disconnect the platform control box and remove from the machine.
2. Place the platform control box on a suitable work bench.
3. Loosen and remove the long through bolts that hold the two side control housings together.

**NOTE:** You may have to only loosen the two power bolts and remove the two closest the top in order to get to the printed circuit board located in the top of the control box where the drive/lift select switch is located.

4. Loosen and remove the four bolts that hold the bottom of the control box.
5. Disconnect the plug from the printed circuit board.
6. Remove the bolts attaching the printed circuit board to the control box.
7. Replace board and reassemble control box.



## Joystick Controller

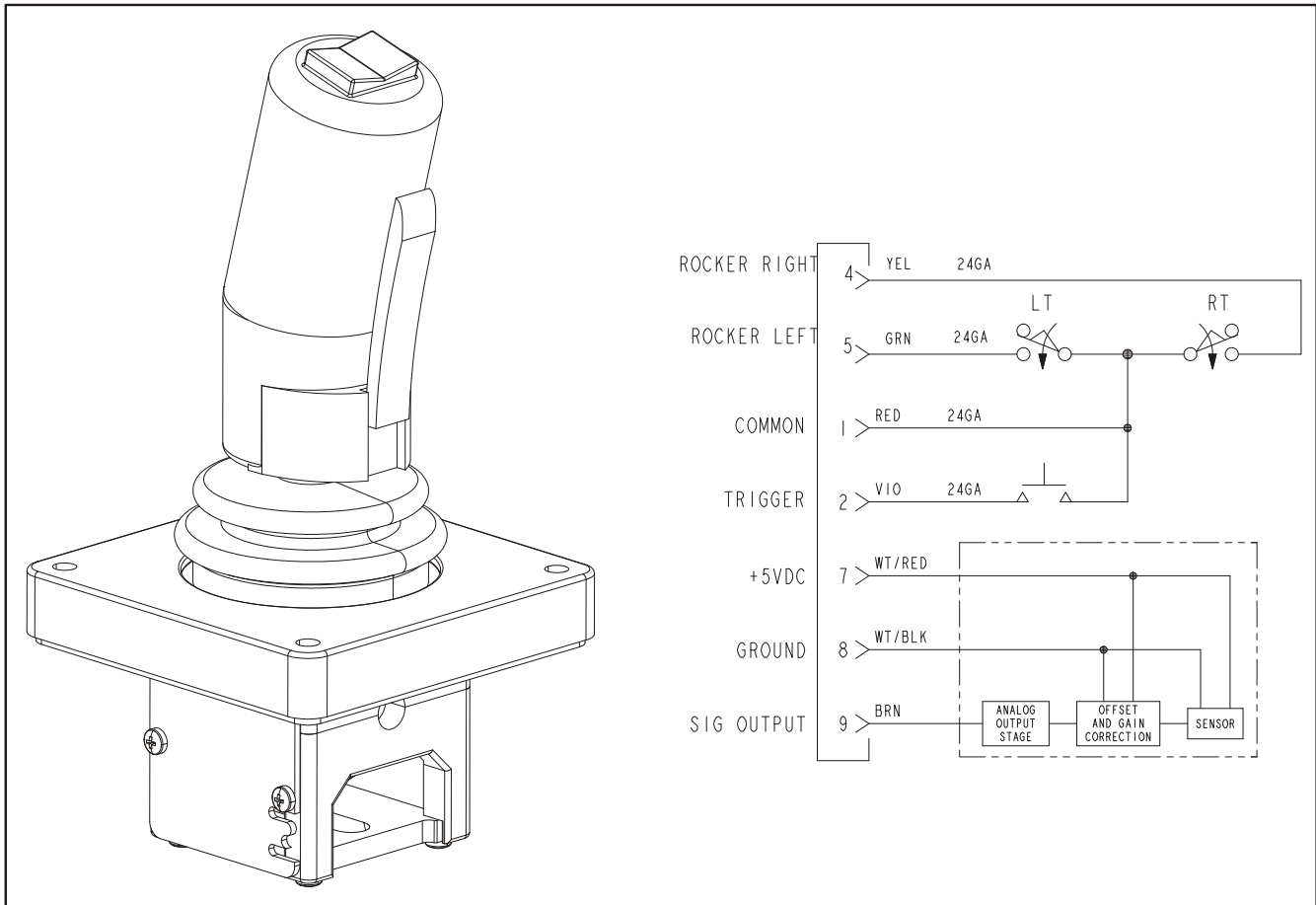


Figure 3-48. Joystick

Table 3-9. Joystick Specifications

Input Voltage	+5 (±0.1) VDC
Current Consumption	10 mA @ 12 VDC
Output: Handle Centered	2.5 (±0.1) VDC
Output: Full Positive (Reverse) Deflection	4 (±0.1) VDC
Output: Full Negative (Forward) Deflection	1 (±0.1) VDC

Table 3-10. Connector Chart

CONNECTOR PINOUT		
Term	Color	Function
1	RED	HANDLE COM
2	VIOLET	TRIGGER N.O.
3	--	SPARE
4	YELLOW	ROCKER RT
5	GREEN	ROCKER LT
6	--	SPARE
7	WHITE/RED	+5VDC
8	WHITE/BLACK	GROUND
9	BROWN	SIG OUTPUT

## SECTION 4. HYDRAULICS

### 4.1 CYLINDERS - THEORY OF OPERATION

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 Lift circuit to prevent retraction of the cylinder rod should a hydraulic line rupture or a leak develop between the cylinder and its related control valve.

### 4.2 VALVES - THEORY OF OPERATION

#### 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.

#### Manual Descent Valve

The manual descent valve is located on 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 power is lost.

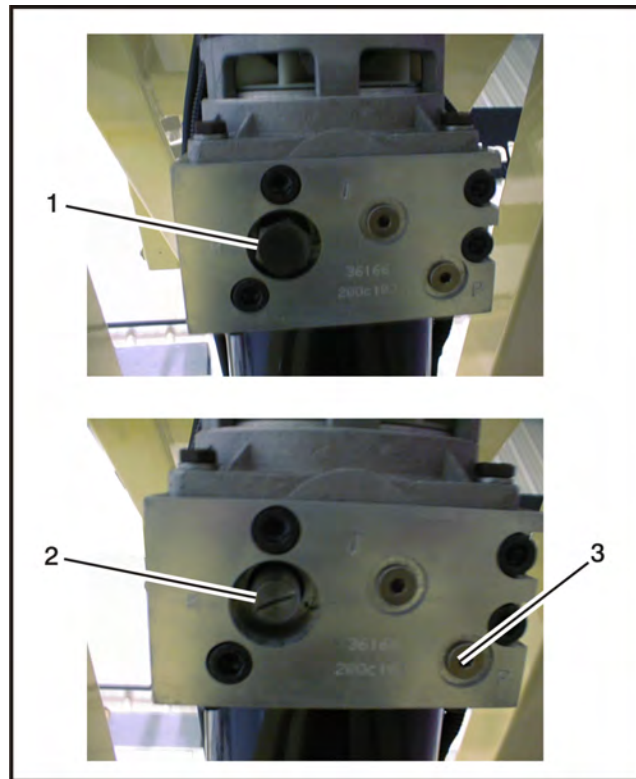
### 4.3 CYLINDER CHECKING PROCEDURE

**NOTE:** Cylinder check must be performed anytime a system component is replaced or when improper system operation is suspected.

#### Cylinders Without Counterbalance Valves and Steer Cylinder

1. Using all applicable safety precautions, activate pump motor and fully extend cylinder to be checked.
2. Carefully disconnect hydraulic hoses from retract port of cylinder. There will be some initial weeping of hydraulic fluid which can be caught in a suitable container. After the initial discharge, there should be no further drainage from the retract port.
3. Activate pump motor and extend cylinder.
4. If cylinder retract port leakage is less than 6-8 drops per minute, carefully reconnect hose to port and retract cylinder. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repair must be made.
5. With cylinder fully retracted, shut down machine power and carefully disconnect hydraulic hose from cylinder extend port.
6. Activate pump motor and retract cylinder. Check extend port for leakage.
7. If extend port leakage is less than 6-8 drops per minute, carefully reconnect hose to extend port, than activate cylinder through one complete cycle and check for leaks. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repairs must be made.

### 4.4 LIFT PRESSURE SETTING PROCEDURE



1. Large Nut
2. Pressure Setting Screw
3. P port

**Figure 4-1. Lift Pressure Setting**

1. Place 120% of the rated load of the machine on the platform.
2. Increase lift pressure to raise the platform and set the safety prop.
3. Locate the Large Nut (1) on the underside of the valve block.
4. Using a 7/8 in. wrench, remove the large nut (1). This will expose the Pressure Setting Screw (2).
5. Remove plug from P port (3) and install a pressure gauge.
6. Raise the platform and take a pressure reading.
7. Adjust the Pressure Setting Screw to reach the proper lift pressure per model as listed in Table 4-1.



**Table 4-1. Lift Pressure Settings**

Model	Lift Relief	Steer Relief
1930ES	1800 psi ± 50 psi (124 bar ± 3.5 bar)	1500 psi (103.4 bar)
2030ES	1800 psi ± 50 psi (124 bar ± 3.5 bar)	1500 psi (103.4 bar)
2630ES	1950 psi +/- 50 psi (134.5 bar ± 3.5 bar)	1500 psi (103.4 bar)
2646ES	2000 psi +/- 50 psi (138 bar ± 3.5 bar)	1500 psi (103.4 bar)
3246ES	2000 psi +/- 50 psi (138 bar ± 3.5 bar)	1500 psi (103.4 bar)

8. Remove pressure gauge and replace the plug into the P port.
9. Replace the bronze washer with a new bronze washer and large nut over the pressure setting screw. Do not use old bronze washer. Using the old bronze washer will cause leakage.
10. Torque the large nut to 160 in. lb (16 Nm).

**Alternate Lift Pressure Setting Procedure:**

1. Increase lift pressure to raise the platform and set the safety prop.
2. Remove plug from port P (3) and install a pressure gauge.
3. Remove the solenoid from the lift valve.
4. Set the pressure actuating lift function from the ground or platform.
5. Remove the pressure gauge from port P (3) and replace plug.
6. Replace the solenoid on the lift valve.

**4.5 HYDRAULIC OIL FILL**

**NOTE:** The hydraulic oil level should be checked every 6 months. Always check the oil level any time any maintenance is performed that would effect the hydraulic oil level.

**Oil Check Procedure**

1. With the scissor lift on a flat and level surface and the platform empty, elevate machine and swing safety prop out of it's stowed position.
2. Continue to elevate the platform until the fill plug, located on the right side of the tank attached to the lift cylinder, is fully accessible.

**CAUTION**

**ENSURE THE SCISSOR ARMS ARE PROPERLY SUPPORTED.**

**NOTE:** The 2630ES/2646ES/ 3246ES platforms will have to be raised higher than the 1930ES and 2030ES in order to access the oil plug.



3. Wipe all dirt and debris from the filler plug area.
4. Slowly remove the fill plug venting any pressure that may be built up in the reservoir.
5. To check the oil level, lower platform so it rests on the safety prop.

**CAUTION**

**THERE MAY BE UP TO 10 PSI OF PRESSURE IN THE TANK.**

6. With the plug removed, the oil level should be completely full, at the top of the fill port with scissor arms resting on the safety prop. from the fill port.
7. If additional oil is required, add proper grade of oil by using a funnel with a flexible spout or a plastic squeeze bottle. Fill until oil weeps out of opening.

**NOTE:** Care should be taken not to introduce any impurities (dirt, water etc.) while plug is removed.

8. Replace plug and torque to 40 ft. lbs. (56 Nm).
9. Any time a hydraulic component is removed or replaced, cycle the scissor arms several times and refer to steps 3 and 4 to recheck oil level.

### Slide Block Lubrication

Lube - White Lithium Grease (GREDAG 741)

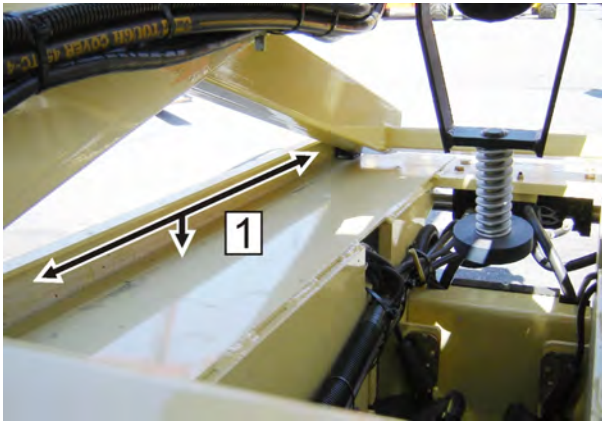
Interval - Every 6 months

1. With the platform empty, elevate machine and swing safety prop out of it's stowed position.

#### **CAUTION**

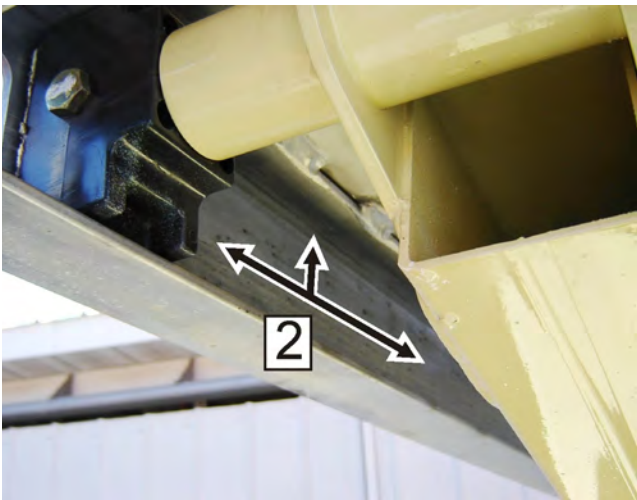
#### **ENSURE THE SCISSOR ARMS ARE PROPERLY SUPPORTED.**

2. Locate the Lower and Upper Slide Pads and wipe/pressure wash all dirt and debris from the slide channel area (1, 2).
3. Apply a layer of grease along the inside and bottom of the lower slide channel (1) on both sides of the machine.



Lower Slide Pad Channel

4. Apply a layer of grease along the inside and top of the upper slide channel (2) on both sides of the machine.



Upper Slide Pad Channel

### 4.6 LIFT CYLINDER REMOVAL

**NOTE:** If there is a pump failure, a crane or a forklift can be used to raise the platform. Refer to Figure 3-47., Arms and Platform Positioning and Support.

Self locking fasteners, such as nylon insert and thread deforming locknuts, are not intended to be reinstalled after removal. Always use new replacement hardware when installing locking fasteners.

1. Raise the platform and place on the safety prop. It may be necessary to use an overhead crane or fork truck to secure the platform and scissor arms before lift cylinder removal begins. (See Figure 3-47.)
2. Cut any wire ties that attach any cables or hoses to the lift cylinder.

#### **NOTICE**

**PULL THE BATTERY DISCONNECT BEFORE REMOVING ANY COMPONENTS FROM THE LIFT CYLINDER ASSEMBLY.**

3. Remove the valves connectors, the two battery cables and the manual decent cable.

**NOTE:** To avoid having to readjust the manual descent, remove the large nut located behind the manual descent bracket as shown. (See Figure 4-2.)

4. Ensuring that the deck and scissor arms are properly secure, remove the top lift cylinder pin and rest the top of the cylinder on the arm cross tube directly below the cylinder.
5. Remove the bolt from the lower cylinder pin and have someone assist you in lifting the cylinder from the scissor arms.
6. Set the cylinder with pump and motor assembly intact on a clean workbench.
7. Remove the 4 bolts that attach the pump/motor assembly to the lift cylinder.
8. Remove the bolt from the bracket that attaches the hydraulic reservoir to the lift cylinder.
9. Separate the cylinder from the pump/motor assembly.



1. Battery Cables  
2. Valves

3. Manual Descent  
4. Steer Hoses

5. Top Cylinder Bolt (*Torque 41 ft. lb.*)  
6. Bottom Cylinder Bolt

**Figure 4-2. Lift Cylinder Removal**

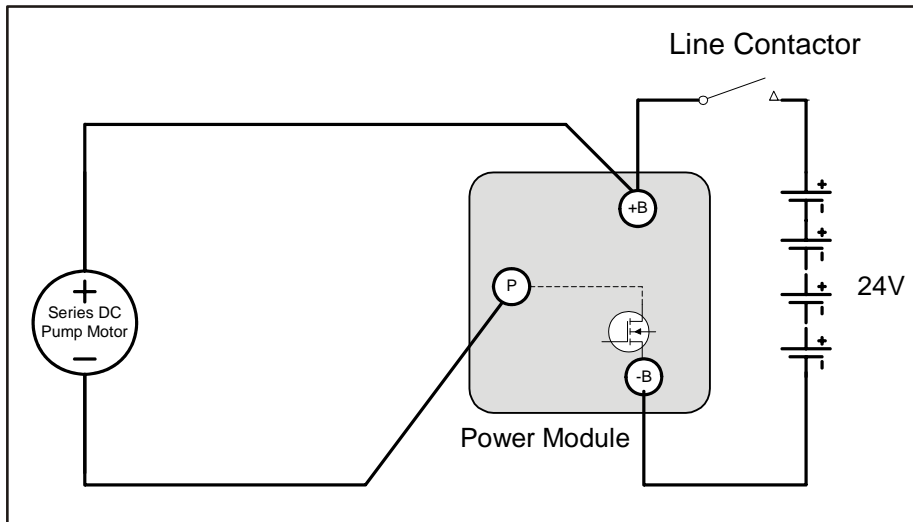
## 4.7 PUMP/MOTOR

### Theory of Operation

The Power Module (see Figure 3-32., Sevcon Power Module Location on page 3-38) 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 (16kHz). 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.

Refer to Figure 7-2., Resistance Measurement. Make all measurements with a voltmeter set to resistance scale (Ohms). Disconnect the Main Battery Disconnect and all pump motor cables during this analysis.

- **Resistance < 5 Ohms 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 > 1 MegaOhms 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.

### Common Difficulties

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 battery compartment. The vehicle should be placed on a firm, level surface for all analysis.

#### 1. **Open-Circuit between +B Terminal and Pump Motor Positive Terminal**

This issue will allow the vehicle to drive, but Lift Up and Steer Functionality 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 drive, but Lift Up and Steer Functionality 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 drive, but Lift Up and Steer Functionality 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.

Pull the Main Battery Disconnect 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 the Main Battery Disconnect.

#### 4. **Short-Circuit between Pump Motor Positive and Negative Terminals**

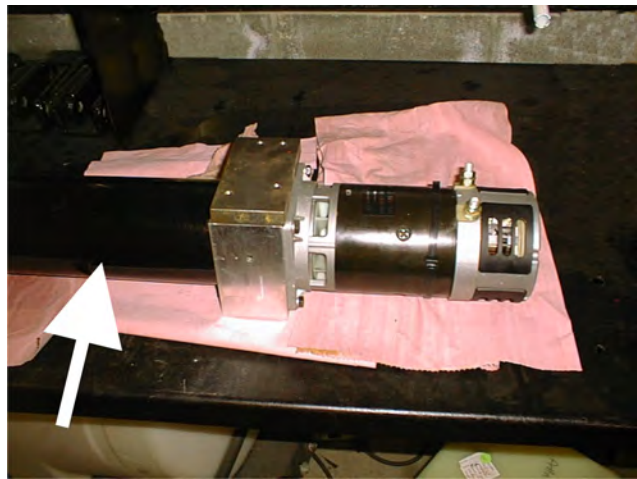
This issue will allow the vehicle to drive, but Lift Up and Steer Functionality will be lost and the Pump Motor will not operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show an erratic reading for PUMP PWM % and PUMP CUR will hover around 150A when Lift Up is operated from Ground Mode.

Pull the Main Battery Disconnect to completely de-energize the Control System. Next, detach both Pump Motor Terminals and insulate them independently. Re-connect the Main Battery Disconnect 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 pot-hole mechanism). 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.

### Pump Removal



1. Place the pump/motor assembly on a clean workbench.

**NOTE:** Drain the hydraulic oil by carefully removing the oil fill plug located on the left side of the hydraulic reservoir.

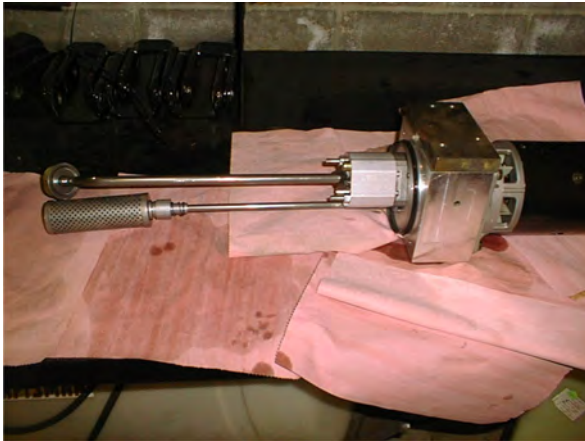
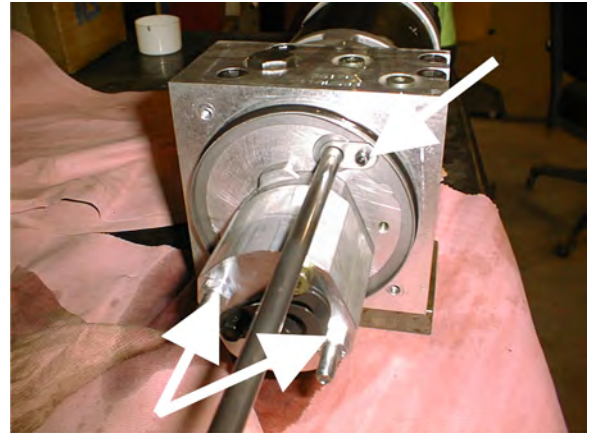


2. Remove the oil tank from the lift cylinder as follows:
  - a. Slowly loosen and remove the four bolts that hold the tank on to the cylinder.
  - b. Carefully remove the tank from the valve body taking care not to damage internal pickup tube or o-ring gasket on tank.
  - c. Place tank on a suitable work bench or work area.

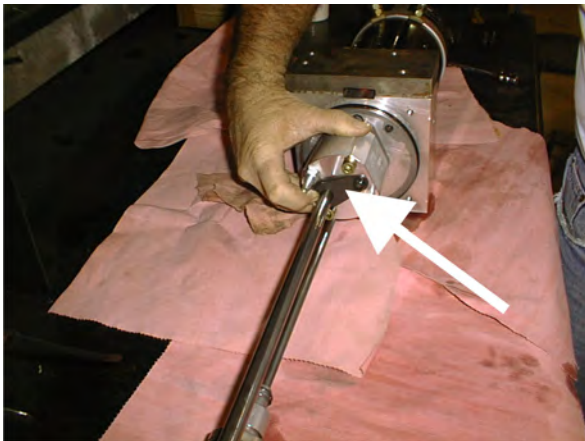
**NOTE:** The filter and bypass are located on the pickup tube inside the tank.

*The filter should be changed once a year.*

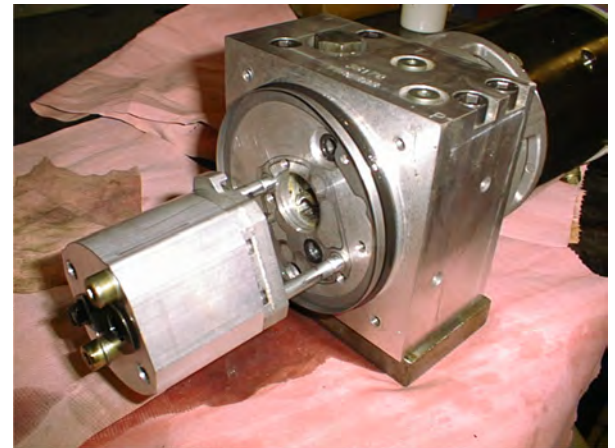
3. If replacing filter, pull old filter off the end of the tube and push new filter onto the end of tube.
4. Thoroughly clean the tank and clean any debris from the magnet.
5. Wipe out tank with clean, lint free rag, taking care not to introduce debris or dirt.
6. Replace the tank. Torque mounting bolts to 20-25 in-lb.
7. If only replacing the oil filter and maintenance is complete, reinstall cylinder assembly on machine, remove fill plug and refill tank with proper grade of oil by using a funnel. Fill until oil weeps out of opening.
8. Replace plug and torque to 40 ft. lbs (56 Nm).

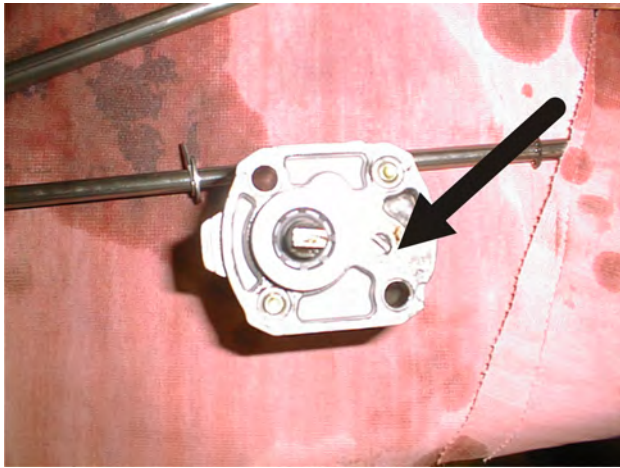


11. Remove allen nut on the return/filter line and rotate large retainer ring to remove return/filter line.
12. Replace the return/filter line oring if necessary.
13. With the return line and the pickup tube removed, the pump can be removed.
14. Loosen and remove the two hexhead nuts from the pump and block. Remove pump from valve body.

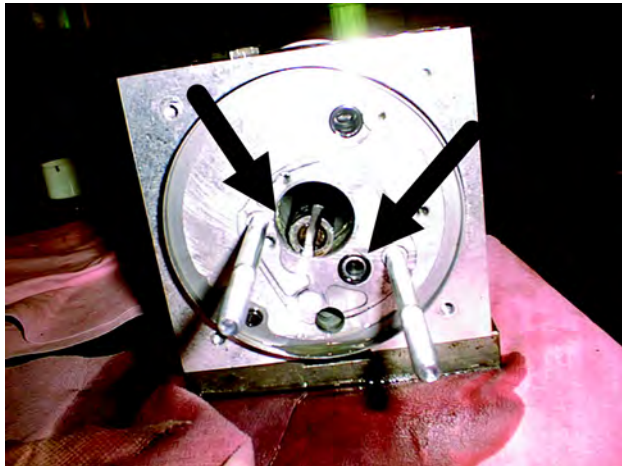


9. To remove the oil pickup line, squeeze retainer and slide outward.
10. Replace the o-ring if necessary.





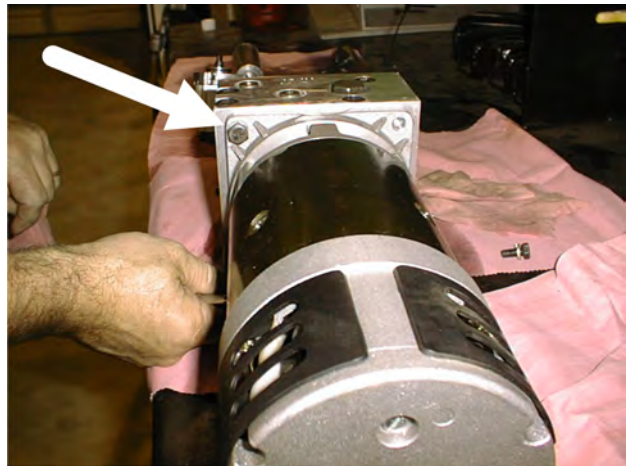
**NOTE:** Be sure to remove and discard the plastic plug at the oil inlet on the new pump before installing.



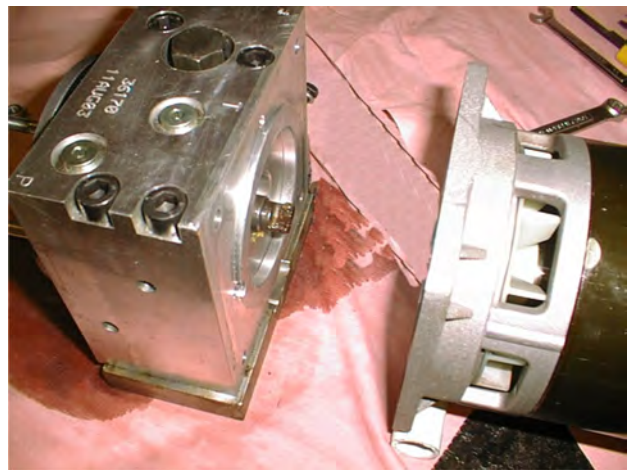
15. Check oring on valve body and replace if necessary before installing the new pump. Lubricate orings before assembling.

**NOTE:** There are two orings used to seal the pump to the valve body, one for the pump inlet (shown above) and one on the pump boss around the drive coupler.

### Motor Removal



1. Remove the four bolts attaching the motor to the valve body.



2. Pull motor from valve body.
3. Once all maintenance is performed and lift cylinder assembly is reinstalled on the machine, remove fill plug and refill tank with proper grade of oil by using a funnel. Fill until oil weeps out of opening.
4. Replace plug and torque to 40 ft. lbs.



## 4.8 CYLINDER REPAIR

**NOTE:** The following are general procedures that apply to all of the cylinders on this machine. Procedures that apply to a specific cylinder will be so noted.

### Disassembly

#### NOTICE

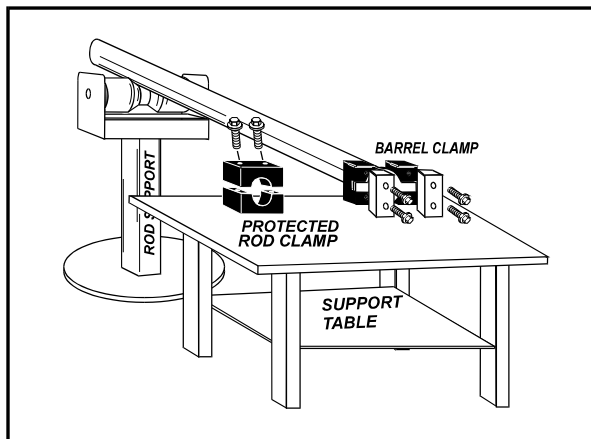
**DISASSEMBLY OF THE CYLINDER SHOULD BE PERFORMED ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA.**

1. Connect a suitable auxiliary hydraulic power source to the port block fitting in the manifold located on the cylinder.

#### ⚠ WARNING

**DO NOT FULLY EXTEND CYLINDER TO THE END OF STROKE. RETRACT CYLINDER SLIGHTLY TO AVOID TRAPPING PRESSURE.**

2. Operate the hydraulic power source and extend the cylinder. Shut down and disconnect the power source. Adequately support the cylinder rod, if applicable.
3. If applicable, remove the cartridge-type holding valve and fittings from the cylinder port block. Discard o-rings.
4. Place the cylinder barrel into a suitable holding fixture.



**Figure 4-3. Cylinder Barrel Support**

5. Mark cylinder head and barrel with a center punch for easy realignment. Loosen the cylinder head setscrew.

**NOTE:** Steps 6 and 7 apply only to the steer cylinder.

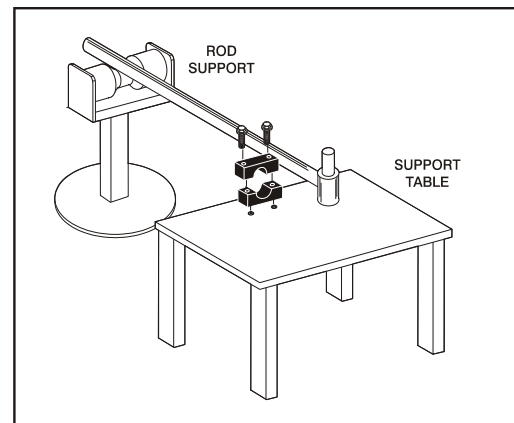
6. Using a spanner wrench, loosen the spanner nut retainer, and remove spanner nut from cylinder barrel.

7. Being careful not to mar the surface of the rod, use a punch or wooden dowel and hammer to drive the rod guide about one inch down into the cylinder bore. Using a screw driver, carefully push one end of the round retaining ring back towards the inside of the cylinder and then slip the screwdriver tip under that end. Pull the ring out of the groove toward the wall mouth. Once one end of the retaining ring is free from the groove, the remainder can be easily pried free using ones fingers or pliers.
8. Attach a suitable pulling device to the cylinder rod port block end or cylinder rod end, as applicable.

#### NOTICE

**EXTREME CARE SHOULD BE TAKEN WHEN REMOVING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.**

9. With the barrel clamped securely, apply pressure to the rod pulling device and carefully withdraw the complete rod assembly from the cylinder barrel.



**Figure 4-4. Cylinder Rod Support**

10. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to the piston as possible.

**NOTE:** For steer cylinder piston removal, see *Steer Cylinder Piston Removal - Cyl. p/n-1684456* on page 4-12 following.

11. Loosen and remove the cap screw(s), if applicable, which attach the tapered bushing to the piston.
12. Insert the cap screw(s) in the threaded holes in the outer piece of the tapered bushing. Progressively tighten the cap screw(s) until the bushing is loose on the piston.
13. Remove the bushing from the piston.

## SECTION 4 - HYDRAULICS

14. Screw the piston CCW, by hand, and remove the piston from cylinder rod.
15. Remove and discard the piston o-rings, seal rings, and backup rings.
16. If applicable, remove the piston spacer from the rod.
17. Remove the rod from the holding fixture. Remove the cylinder head gland and retainer plate, if applicable. Discard the o-rings, back-up rings, rod seals, and wiper seals.

### Steer Cylinder Piston Removal - Cyl. p/n-1684456

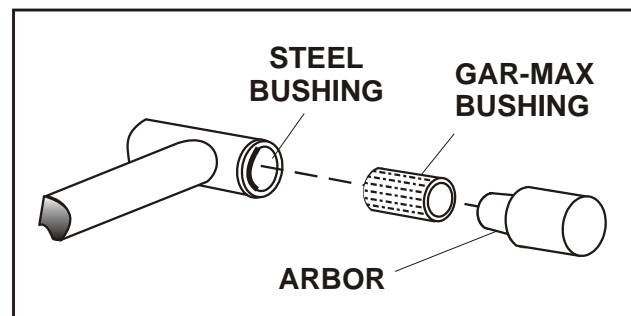
1. Using the spanner holes, rotate the piston until the end of the retaining ring can be seen through the cross-drilled retaining ring hole.
2. Insert a flathead screwdriver (or similar tool) into the cross-drilled retaining ring hole.
3. Using the screwdriver, guide the retaining ring into the cross-drilled retaining ring hole while turning the piston.
4. Continue turning the piston approximately one (1) full turn until the start of the retaining ring is again aligned with the cross-drilled retaining ring hole.
5. Lift up on the retaining ring so that the hook on the start of the retaining ring releases from the hole in the rod.
6. Pull the retaining ring all the way out of the cross-drilled retaining ring hole.
7. Slide the piston over the rod in the direction of the spanner holes to remove.

### Cleaning and Inspection

1. Clean all parts thoroughly in an approved cleaning solvent.
2. Inspect the cylinder rod for scoring, tapering, ovality, or other damage. If necessary, dress rod with Scotch Brite or equivalent. Replace rod if necessary.
3. Inspect threaded portion of rod for excessive damage. Dress threads as necessary.
4. Inspect inner surface of cylinder barrel tube for scoring or other damage. Check inside diameter for tapering or ovality. Replace if necessary.
5. Inspect threaded portion of barrel for damage. Dress threads as necessary.
6. Inspect piston surface for damage and scoring and for distortion. Dress piston surface or replace piston as necessary.
7. Inspect threaded portion of piston for damage. Dress threads as necessary.

8. Inspect seal and o-ring grooves in piston for burrs and sharp edges. Dress applicable surfaces as necessary.
9. Inspect cylinder head inside diameter for scoring or other damage and for ovality and tapering. Replace as necessary.
10. Inspect threaded portion of head for damage. Dress threads as necessary.
11. Inspect seal and o-ring grooves in head for burrs and sharp edges. Dress applicable surfaces as necessary.
12. Inspect cylinder head outside diameter for scoring or other damage and ovality and tapering. Replace as necessary.
13. If applicable, inspect rod and barrel bearings for signs of correct excessive wear or damage. Replace as necessary.
  - a. Thoroughly clean hole, (steel bushing) of burrs, dirt etc. to facilitate bearing installation.
  - b. Inspect steel bushing for wear or other damage. If steel bushing is worn or damaged, rod/barrel must be replaced.
  - c. Lubricate inside of steel bushing with WD40 prior to bearing installation.
  - d. Using an arbor of the correct size, carefully press the bearing into steel bushing.

**NOTE:** Install pin into the Gar-Max bearing dry. Lubrication is not required with nickel plated pins and bearings.



**Figure 4-5. Gar-Max Bearing Installation**

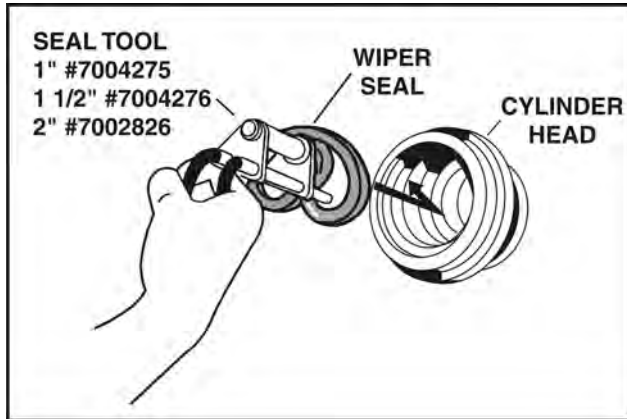
14. Inspect travel limiting collar or spacer for burrs and sharp edges. If necessary, dress inside diameter surface with Scotch Brite or equivalent.
15. If applicable, inspect port block fittings and holding valve. Replace as necessary.
16. Inspect the oil ports for blockage or the presence of dirt or other foreign material. Repair as necessary.
17. If applicable, inspect piston rings for cracks or other damage. Replace as necessary.

**Assembly**

**NOTE:** Prior to cylinder assembly, ensure that the proper cylinder seal kit is used. See your JLG Parts Manual (3121167).

Apply a light film of hydraulic oil to all components prior to assembly.

1. A special tool is used to install a new rod seal into the applicable cylinder head gland groove.

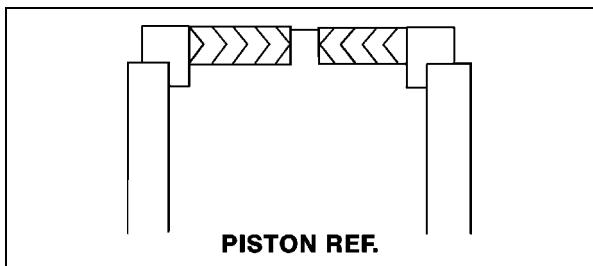


**Figure 4-6. Rod Seal Installation**

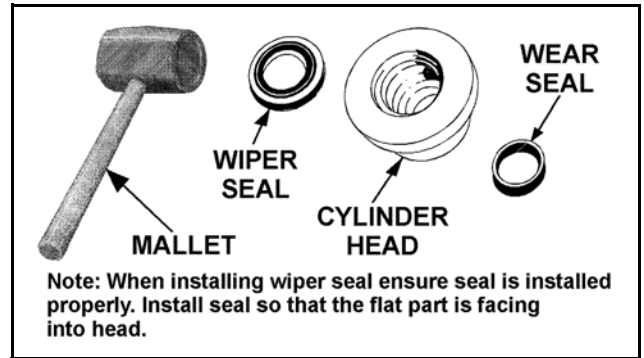
**NOTICE**

**WHEN INSTALLING 'POLY-PAK' PISTON SEALS, ENSURE SEALS ARE INSTALLED PROPERLY. REFER TO WIPER SEAL INSTALLATION FOR CORRECT SEAL ORIENTATION. IMPROPER SEAL INSTALLATION COULD RESULT IN CYLINDER LEAKAGE AND IMPROPER CYLINDER OPERATION.**

2. Use a soft mallet to tap a new wiper seal into the applicable cylinder head gland groove. Install a new wear ring into the applicable cylinder head gland groove.

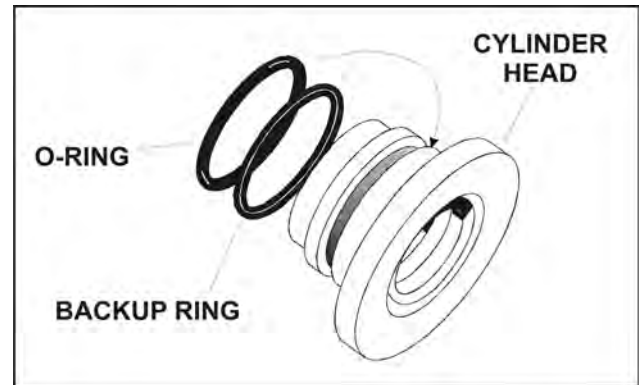


**Figure 4-7. Poly-Pak Piston Seal Installation**



**Figure 4-8. Wiper Seal Installation**

3. Place a new "O-ring and back-up seal in the applicable outside diameter groove of the cylinder head.



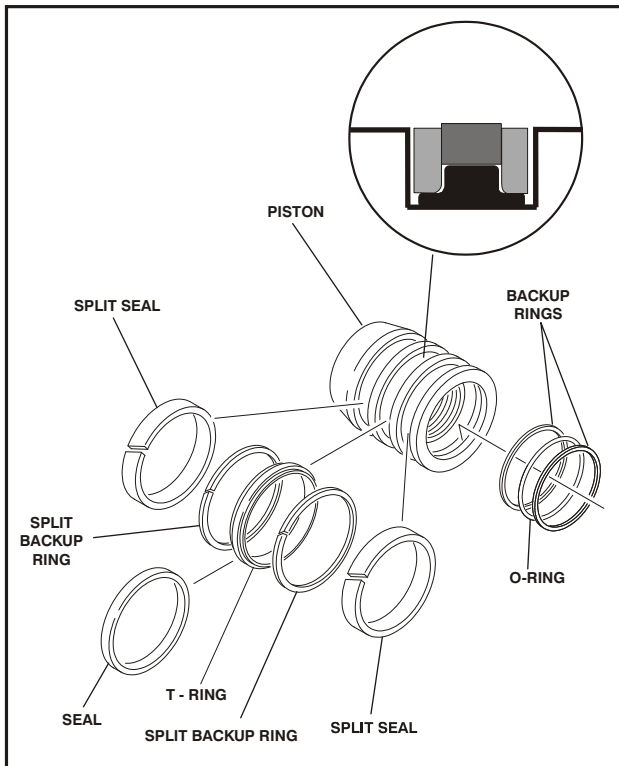
**Figure 4-9. Installation of Head Seal Kit**

4. Install washer ring onto rod, carefully install the head gland on the rod, ensuring that the wiper and rod seals are not damaged or dislodged. Push the head along the rod to the rod end, as applicable.
5. Carefully slide the piston spacer on the rod.

**NOTE:** Upper telescope cylinder piston has an o-ring installed inside the spacer.

6. If applicable, correctly place new o-ring in the inner piston diameter groove. (The backup ring side facing the O-ring is grooved.)
7. If applicable, correctly place new seals and guide lock rings in the outer piston diameter groove. (A tube, with I.D. slightly larger than the O.D. of the piston is recommended to install the solid seal.)

**NOTE:** The backup rings for the solid seal have a radius on one side. This side faces the solid seal. (See magnified insert in Figure 4-9. The split of seals and backup rings are to be positioned so as not to be in alignment with each other.)



**Figure 4-10. Piston Seal Kit Installation**

1. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to piston as possible.
2. Carefully thread the piston on the cylinder rod hand tight, ensuring that the o-ring and back-up rings are not damaged or dislodged.
3. Thread the piston onto the rod until it abuts the spacer end and install the tapered bushing.

**NOTE:** When installing the tapered bushing, piston and mating end of rod must be free of oil.

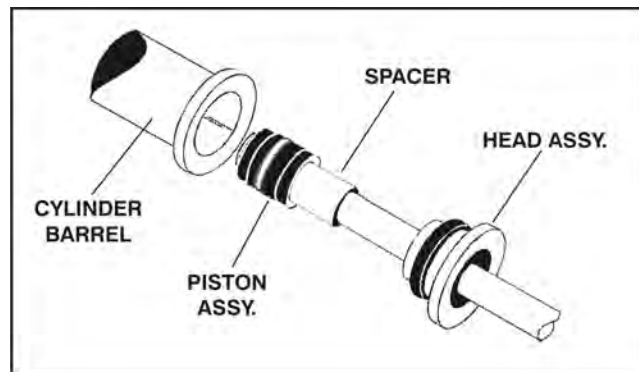
4. Assemble the tapered bushing loosely into the piston and insert JLG capscrews (not vendor capscrews) through the drilled holes in the bushing and into the tapped holes in the piston.
5. Tighten the capscrews evenly and progressively in rotation to the specified torque value.
6. After the screws have been torqued, tap the tapered bushing with a hammer (16 to 24 oz.) and brass shaft (approximately 3/4" in diameter) as follows;
  - a. Place the shaft against the cylinder rod and in contact with the bushing in the spaces between the capscrews.
  - b. Tap each space once; this means the tapered bushing is tapped 3 times as there are 3 spaces between the capscrews.

7. Retorque the capscrews evenly and progressively in rotation to the specified torque value.
8. Remove the cylinder rod from the holding fixture.
9. Place new guide locks and seals in the applicable outside diameter grooves of the cylinder piston. (See Figure 4-10.)
10. Position the cylinder barrel in a suitable holding fixture.

**NOTICE**

**EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.**

11. With the barrel clamped securely, and while adequately supporting the rod, insert the piston end into the barrel cylinder. Ensure that the piston loading o-ring and seal ring are not damaged or dislodged.
12. Continue pushing the rod into the barrel until the cylinder head gland can be inserted into the barrel cylinder.
13. Secure the cylinder head gland using the washer ring and socket head bolts.



**Figure 4-11. Rod Assembly Installation**

14. After the cylinder has been reassembled, the rod should be pushed all the way in (fully retracted) prior to the reinstallation of any holding valve or valves.
15. If applicable, install the cartridge-type holding valve and fittings in the rod port block, using new o-rings as applicable. (See Table 4-3, Holding Valve Torque Specifications).

**Table 4-2. Cylinder Piston Nut Torque Specifications**

Description	Nut Torque Value	Setscrew torque Value
Lift Cylinder	250-300 ft lb (339-407 Nm)	N/A

16. Push the piston onto the rod until it abuts the spacer end and install the attaching nut.

**Table 4-3. Holding Valve Torque Specifications**

Description	Torque Value
Integrated Steer	15 ft lb (20Nm)
Integrated Proportional Valve	15 ft lb (20Nm)
Integrated Blocking Valve	15 ft lb (20Nm)
Relief	33 ft lb (45 Nm)
Coil Nuts	Hand Tighten

**⚠ WARNING**

**WHEN REBUILDING THE CYLINDERS, APPLY LOCTITE #242 TO THE PISTON NUT AND SETSCREW, THEN TORQUE PISTON NUT. REFER TO TABLE 4-2, CYLINDER PISTON NUT TORQUE SPECIFICATIONS.**

**NOTE:** Reverse the procedure Steer Cylinder Piston Removal - Cyl. p/n-1684456 on page 4-12 for installing the steer cylinder piston.

17. Remove the cylinder rod from the holding fixture.
18. Position the cylinder barrel in a suitable holding fixture.

**NOTICE**

**EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.**

19. With barrel clamped securely, and while adequately supporting the rod, insert the piston end into the barrel cylinder. Ensure that the piston loading o-ring and seal ring are not damaged or dislodged.
20. Continue pushing the rod into the barrel until the cylinder head gland can be inserted into the barrel cylinder.
21. If applicable, secure the cylinder head retainer using a suitable chain wrench.
22. After the cylinder has been reassembled, the rod should be pushed all the way in (fully retracted) prior to the reinstallation of any holding valve or valves.
23. If applicable, install the cartridge-type holding valve and fittings in the port block using new o-rings as applicable. Refer to Table 4-3, Holding Valve Torque Specifications.

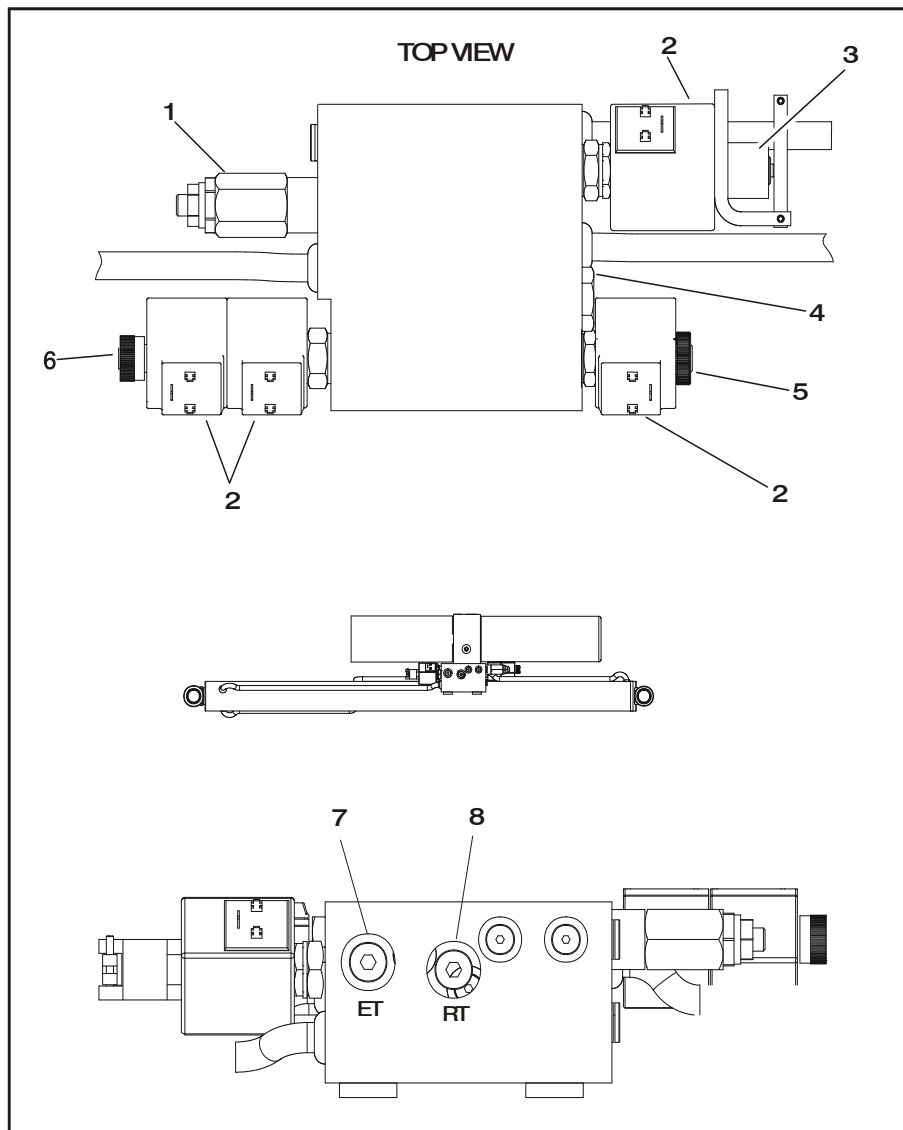
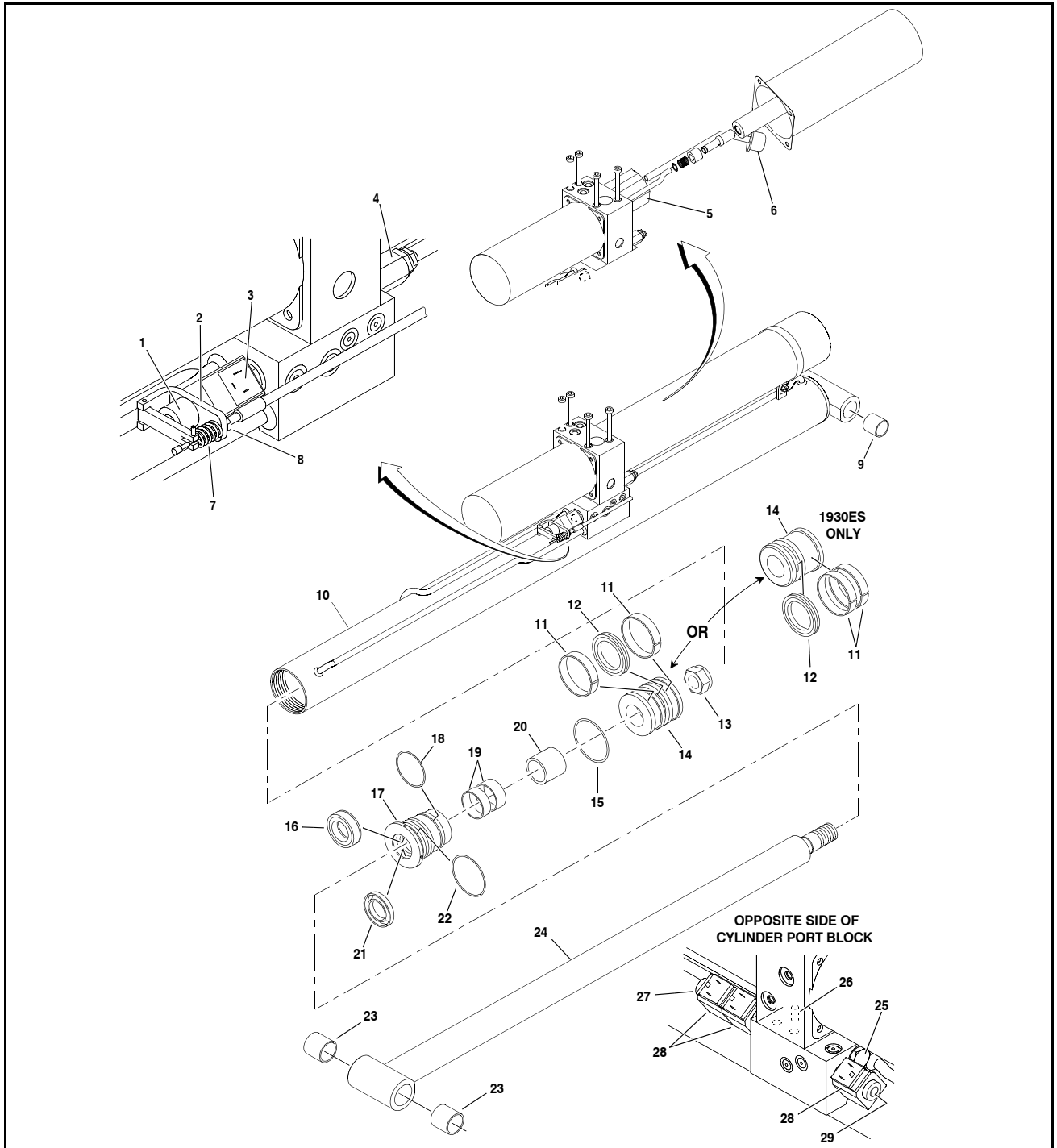


Figure 4-12. Lift Cylinder/Pump/Tank Assembly

Table 4-4. Valve Torque Values

Item	Description	Torque
1	Bi-directional Relief Valve	33 ft lbs (45 Nm)
2	Solenoid	NA
3	Proportional Valve	15 ft lbs (20 Nm)
4	Check Valve	33 ft lbs (45 Nm)
5	Blocking Valve	15 ft lbs (20 Nm)
6	4 Way Directional Valve	15 ft lbs (20 Nm)
7	Extend Port	NA
8	Retract Port	NA



- |                            |               |             |                  |                               |
|----------------------------|---------------|-------------|------------------|-------------------------------|
| 1. Proportional Valve      | 7. Spring     | 13. Locknut | 19. Wear Ring    | 25. Check Valve               |
| 2. Emergency Release Assy. | 8. Jam Nut    | 14. Piston  | 20. Spacer       | 26. Dowel Pin                 |
| 3. Coil                    | 9. Bushing    | 15. O-ring  | 21. Wiper        | 27. Directional Control Valve |
| 4. Relief Valve            | 10. Barrel    | 16. Seal    | 22. O-ring       | 28. Coil                      |
| 5. Pump                    | 11. Wear Ring | 17. Head    | 23. Bushing      | 29. Directional Control Valve |
| 6. Filter                  | 12. Seal      | 18. O-ring  | 24. Cylinder Rod |                               |

Figure 4-13. Lift Cylinder Assembly





## SECTION 5. JLG CONTROL SYSTEM

## 5.1 HAND HELD ANALYZER

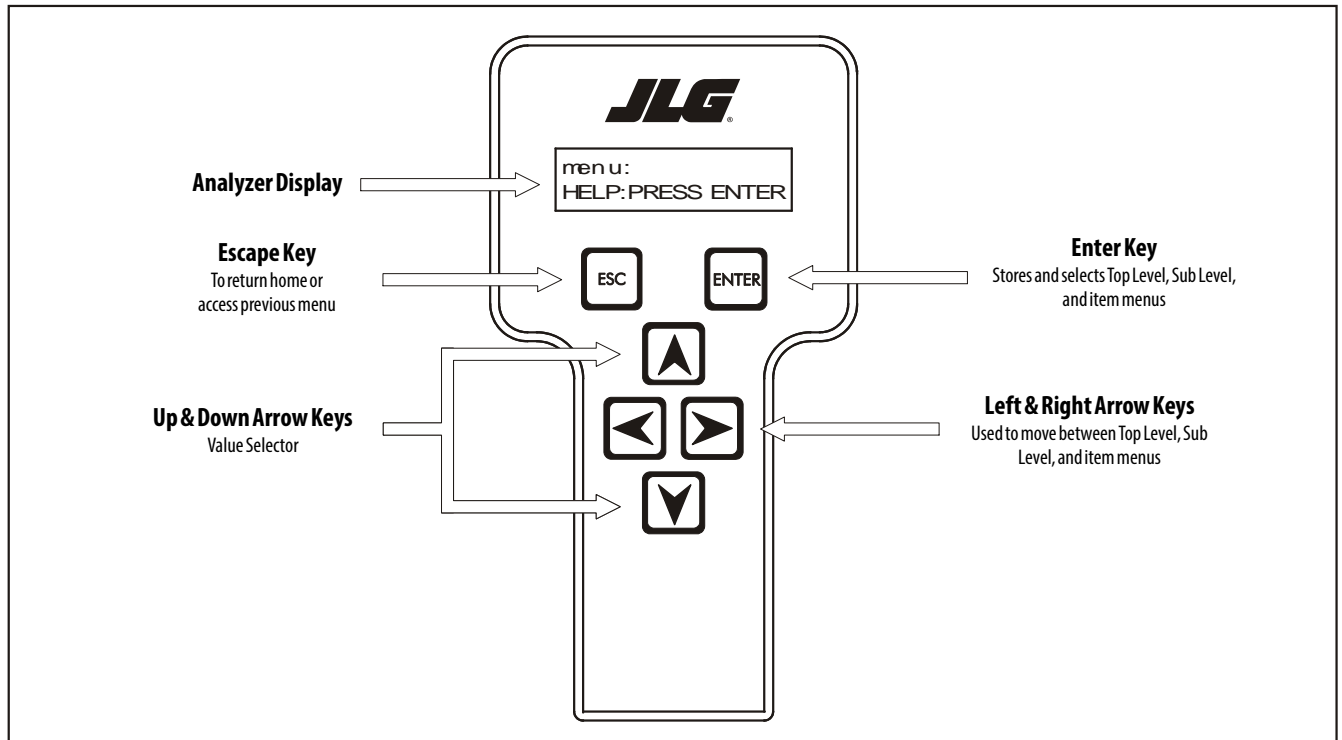


Figure 5-1. Hand Held Analyzer

**To Connect the Hand Held Analyzer:**

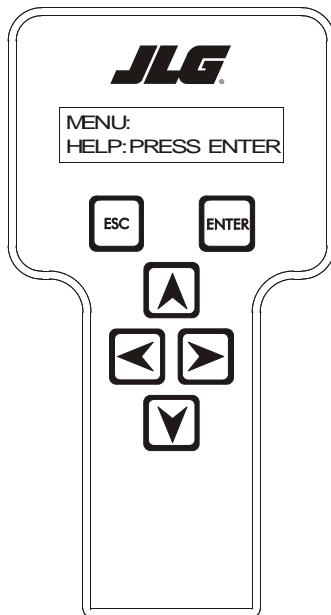
1. Connect the four pin end of the cable supplied with the analyzer, to the diagnostic port (refer to Section 3.1) and connect the remaining end of the cable to the analyzer.

**NOTE:** The cable has a four pin connector at each end of the cable; the cable cannot be connected backwards.

2. Power up the Control System by turning the lower key to the platform position and pulling both emergency stop buttons on.

**Using the Analyzer:**

With the machine power on and the analyzer connected properly, the analyzer will display the following:



**HELP:  
PRESS ENTER**

At this point, using the **RIGHT** and **LEFT** arrow keys, you can move between the top level menu items. To select a displayed menu item, press **ENTER**. To cancel a selected menu item, press **ESC**; then you will be able to scroll using the right and left arrow keys to select a different menu item.

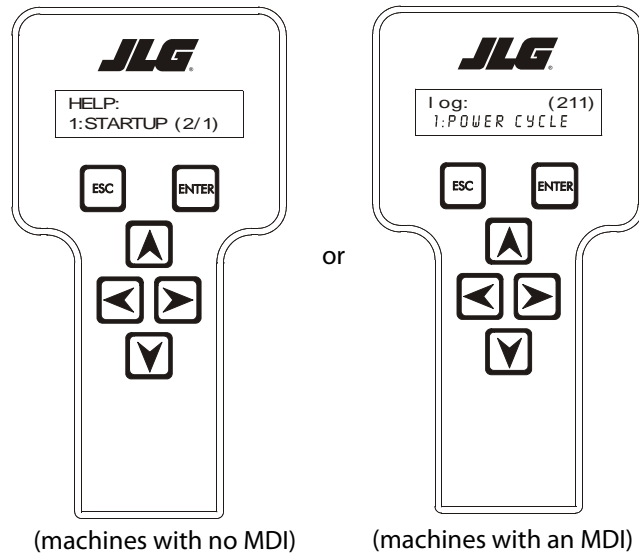
The top level menus are as follows:

- HELP**
- DIAGNOSTICS**
- ACCESS LEVEL**
- PERSONALITIES**
- MACHINE SETUP**
- ACTIVATE TESTS**
- CALIBRATION**

If you press **ENTER**, at the HELP:PRESS ENTER display, and a fault is present, the analyzer display will scroll the fault across the screen. If more than one fault is present only the highest priority fault will show. The other active faults are viewable in Logged Help. If there was no fault detected, the display will read:

- In platform mode,
  - HELP: (001)**
  - EVERYTHING OK,**
- In ground mode,
  - HELP: (002)**
  - GROUND MODE OK**

If **ENTER** is pressed again, the display moves to the following display:



**LOGGED HELP**

- 1: STARTUP (2/1):** (Or last recorded fault)
- LOG: (211)**
- 1: Power Cycle** (Or last recorded fault)

At this point, the analyzer will display the highest priority active fault, if any are present. You may scroll through the fault logs to view what the last fifteen faults were. Use the right and left arrow keys to scroll through the fault logs. The active faults, are listed before the first POWER CYCLE. To return to the top menu, press **ESC** two times.

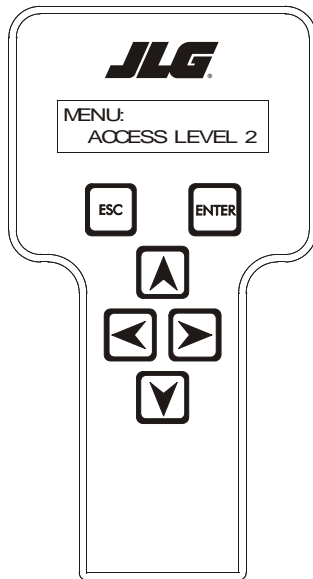
When a top level menu is selected, a new set of menu items may be offered; If for example you choose Personalities:

- DRIVE**
- LIFT**
- STEER**
- GROUND**

Pressing **ENTER** with any of the above displayed menus, will display additional sub-menus within the selected menu. In some cases the next level is the parameter or information to be changed. Refer to the flow chart for what menus are available within the top level menus. You may only view the personality settings for selected menus while in access level 2. Remember, you may always cancel a selected menu item by pressing the **ESC** key.

## Changing the Access Level of the Hand Held Analyzer:

When the analyzer is first connected, you will be in access level 2 which enables you to only view most configuration settings which cannot be changed until you enter a password to advance to a lower level. This ensures that a setting cannot be accidentally altered. To change the access level, the correct password must be entered. To enter the password, scroll to the **ACCESS LEVEL** menu. For example:



### MENU: ACCESS LEVEL 2

Press **ENTER** to select the **ACCESS LEVEL** menu.

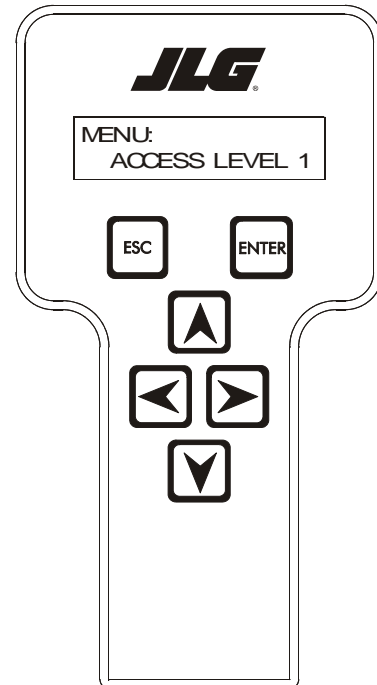
Using the **UP** or **DOWN** arrow keys, enter the first digit of the password, 3.

Then using the **RIGHT** arrow key, position the cursor to the right one space to enter the second digit of the password.

Use the **UP** or **DOWN** arrow key to enter the second digit of the password which is 3.

Repeat this process until you have entered all five digits of the password which is **33271**.

Once the correct password is displayed, press **ENTER**. The access level should display the following, if the password was entered correctly:

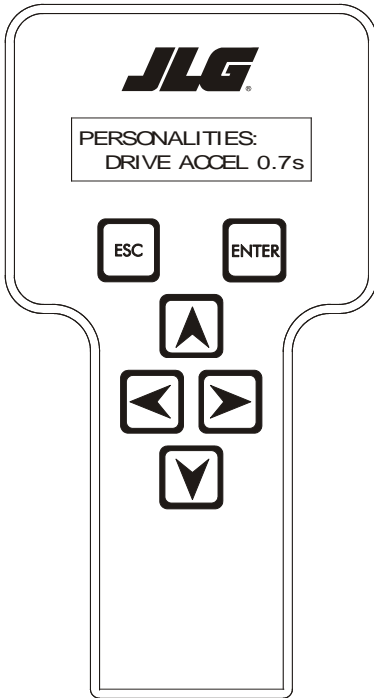


### MENU: ACCESS LEVEL 1

Repeat the above steps if the correct access level is not displayed or you can not adjust the personality settings:

## Adjusting Parameters Using the Hand Held Analyzer

Once you have gained access to level 1, and a personality item is selected, press the UP or DOWN arrow keys to adjust its value, for example:



### PERSONALITIES: DRIVE ACCEL 0.7s

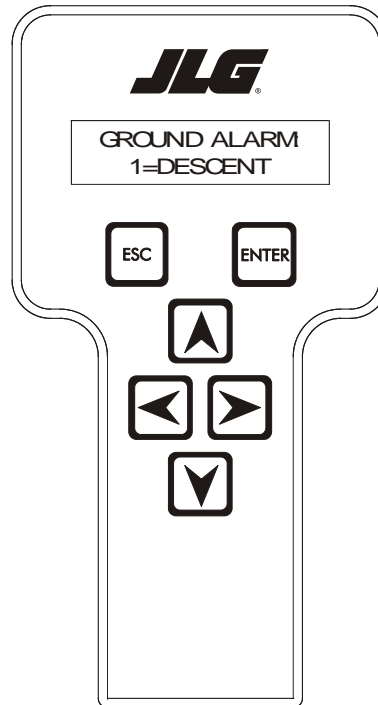
There will be a minimum and maximum for the value to ensure efficient operation. The Value will not increase if the **UP** arrow is pressed when at the maximum value nor will the value decrease if the **DOWN** arrow is pressed and the value is at the minimum value for any particular personality. If the value does not change when pressing the up and down arrows, check the access level to ensure you are at access level 1.

## Machine Setup

When a machine digit item is selected, press the **UP** or **DOWN** arrow keys to adjust its value, for example:

### **⚠ WARNING**

**FAILURE TO MAKE THE PROPER SETTINGS FOR THE PARTICULAR MACHINE CAN RESULT IN IMPROPER OPERATION.**



### GROUND ALARM: 1=DESCENT

The effect of the machine digit value is displayed along with its value. The above display would be selected if the machine was equipped with a ground alarm and you wanted it to sound when driving. There are certain settings allowed to install optional features or select the machine model.

When selecting the machine model to match the size of the machine, the personality settings will return to default settings.

**NOTE:** Refer to Table 5-3, Machine Model Adjustment (Machines with Sevcon - 1600346 Power Module Only), and Table 5-5, Machine Configuration Programming Information (Machines with Sevcon - 1600346 Power Module Only) for the default settings.

Password 33271 will give you access to level 1, which will permit you to change all machine personality and/or machine setup settings.

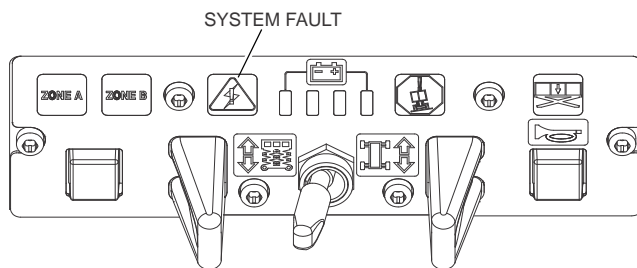
**⚠ WARNING**

CHANGING THESE SETTINGS MAY ADVERSELY AFFECT THE PERFORMANCE OF YOUR MACHINE.

**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 INCHES (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.

The flash code is indicated on the face of the platform control box as shown:



Diagnostic Trouble Codes are indicated on the MDI for those machines that are equipped with an MDI. (refer to Section 3.2).

**NOTE:** Flash codes and DTC's are also displayed on the handheld analyzer. For descriptions see, Table 5-2, Flash Code Listing.

**5.2 TILT SENSOR CALIBRATION**

Be sure that the machine is parked and stowed on level ground.

**NOTE:** Tilt Sensor Calibration can not be performed if the main contactor switch is open due to an alarm.

**Ground Module Software Version 1.5**

1. Enter Access Level 1 and go to the CALIBRATION/TILT SENSOR/LEVEL VEHICLE screen.
2. Choose the right arrow key to view the raw, uncalibrated tilt sensor values. If either raw angle reads  $\pm 5.0$  or more, the machine is too unlevel and the software will prohibit calibration. Therefore, attempt to dissect the three areas of error to find the primary contributor:
  - a. Machine mounting and/or grade:
 

Try to measure the top of the Ground Control box for levelness. If unable to get a good reading, unbolt the Ground Control box and check the box's mounting surface for levelness.
  - b. Tilt sensor mounting on machine or wedged crooked in control box:
 

If the machine mounting/grade appears acceptable, remove and open the Ground Control box carefully. Observe whether the tilt sensor is properly seated in its grooves.
  - c. Tilt sensor has developed an offset shift:
 

Remove the tilt sensor from the Ground Control box but keep both the tilt sensor and Ground Control box electrically connected. Level one axis of the tilt sensor and observe the raw reading (should be within  $\pm 2.0$ ). Do the same for the other axis. If either axis is greater than  $\pm 2.0$ , replace the tilt sensor.

**Ground Module Software Version 1.4**

1. Enter Access Level 1 and go to the CALIBRATION/TILT SENSOR/LEVEL VEHICLE screen.
2. Choose the right arrow key to view the raw, uncalibrated tilt sensor values. If either raw angle reads  $\pm 5.0$  or more, the machine is too unlevel and the software will prohibit calibration. Therefore, attempt to dissect the three areas of error to find the primary contributor:
  - a. Machine mounting and/or grade:
 

Try to measure the top of the Ground Control box for levelness. If unable to get a good reading, unbolt the Ground Control box and check the box's mounting surface for levelness.
  - b. Tilt sensor mounting on machine or wedged crooked in control box:
 

If the machine mounting/grade appears acceptable, remove and open the Ground Con-

trol box carefully. Observe whether the tilt sensor is properly seated.

- c. Tilt sensor has developed an offset shift: Remove the tilt sensor from the Ground Control box but keep both the tilt sensor and Ground Control box electrically connected. Level one axis of the tilt sensor and observe the raw reading (should be within  $\pm 2.0$ ). Do the same for the other axis. If either axis is greater than  $\pm 2.0$ , replace the tilt sensor.

**NOTE:** Check that the tilt switch is properly set by referring to the Tilt Settings table in section 1 of this manual.

### Failure Troubleshooting for The Field

Some possible reasons that the tilt sensor will not calibrate are:

- a. The surface the machine is sitting on is off level by a few degrees (flat doesn't imply level; parking lots are often not level).
- b. The tilt sensor has failed one or both of the channels (X axis and Y axis).
- c. Tilt sensor has moisture intrusion that has shifted its output.
- d. Water and/or corrosion in the box has corrupted electrical connections or caused a tilt sensor or ground control board failure (observe any cracks in the box).
- e. The Ground Control Box, as mounted on the machine, does not allow the tilt sensor to be level.

For the following troubleshooting steps, a bubble level (smaller is better) will be needed and the machine must be on a level surface:

1. On the Analyzer, go to the Diagnostics/System and read the tilt angle. If either angle reports  $+20.0^\circ$ , there is an electrical/electronic failure (tilt sensor, control board, electrical connections).
  - a. Take the Ground Control box off of the machine and open the rear cover.
  - b. Disconnect the sensor and clean any corrosion off of the tilt sensor and control board connections.
  - c. Reassemble and test. If fault persists, replace tilt sensor.
2. If the Analyzer displays angles other than  $+20.0^\circ$ , attempt to calibrate. If machine won't calibrate, note the reason displayed on Analyzer:
  - a. SENSOR FAILURE – tilt sensor internal frequency is out of range (replace sensor).
  - b. NOT LEVEL - tilt sensor has either developed an offset or it is too unlevel as mounted on the machine.

### 5.3 TILT SENSOR ELECTRICAL EVALUATION

This basic check using the JLG Analyzer can be used to test the Tilt Sensor.

- **If angle measurements read  $+20.0$ , then a sensor/wiring/connector fault exists.** If the readings intermittently display expected angles, then there is likely a wiring/connector problem and not a failed sensor. In either case, open the ES Ground box. Disconnect the sensor, check the wire terminations, and clean any corrosion on the tilt sensor and control board connections. Reconnect and test. If the fault persists, replace the tilt sensor and return the faulty tilt sensor to JLG with a detailed description of the diagnostic steps taken.

### 5.4 ELEVATION ANGLE SENSOR ELECTRICAL EVALUATION

These basic checks using the JLG Analyzer can be used to test the Elevation Angle Sensor. If the problem is still occurring, perform the Tilt vs. Allowed Height Evaluation described below.

- **On a level surface, with the Analyzer under DIAGNOSTICS/ELEV SENSOR, verify that the elevation angle sensor voltage increases (ranges from 0.2V-0.8V to 3.6V-4.2V) with platform height.** If not, check the sensor mounting. If necessary, unbolt sensor and rotate by hand while monitoring with the Analyzer to check the integrity of the sensor output.
- **For machines equipped with an elevation proximity switch, if the Elevation Sensor appears satisfactory, verify that the Elevation Prox switch is opening and closing appropriately** by watching the change of state between the stowed and elevated positions (monitor PROX SWITCH under DIAGNOSTICS/ELEV SENSOR). If a change of state is not observed, check prox mounting and operability by placing metal in front of the prox sensor face.

### Tilt vs. Allowed Height Evaluation

First, find a level surface (not just flat like a parking lot; must be level). The surface should be a plane in which the wheels are within  $0^{\circ} \pm 0.2^{\circ}$ . Find this surface by taking a digital level and measuring the areas on which the wheels would rest in both the X and Y directions. Mark the locations and drive the machine to these points. If a level surface can not be found, flat shims or plates may be placed under the wheels to create a level plane for the wheels.

In determining the existing tilt angle, read the angle on the Analyzer under DIAGNOSTICS/SYSTEM. Do not place a hand-held level on the machine to determine whether the machine is level and lifting to the appropriate height. Such a measurement will likely be different than the Ground box/tilt sensor angle reading due to manufacturing and mounting tolerances. The tilt angle in both directions should read within  $\pm 0.5^{\circ}$  while on a level surface. If not, then either the machine has a drifting tilt sensor or has been erroneously re-calibrated since the original factory calibration.

Check the service records to determine whether a re calibration has been performed. If so, re-calibrate on the level surface. If there is no record of an earlier calibration, we must assume that the sensor output has drifted. Therefore, replace the sensor and return to JLG with a detailed troubleshooting description.

**NOTE:** *There is a rare case in which an attempted calibration will be unsuccessful for machines with Ground module software version P1.5 or earlier. If this occurs while performing a calibration, the Analyzer will display:*

LEVEL VEHICLE  
TILT +20.0 +20.0

and the following fault will also be logged.

TILT SENSOR NOT CALIBRATED (2/3) [DTC 811]

If no other faults have been logged since the last startup, this fault indicates that the software needs to be updated to P1.6 or later. Update the software and continue troubleshooting evaluation before replacing any components.

If the tilt sensor readings are within range for a level machine, compare the allowed Tilt vs. Height in the chart below. Being within 6" of the target height is considered acceptable.

Table 5-1. Tilt Settings

Model	Tilt Setting (front to back)	Tilt Setting (side to side)	Maximum Deck Elevation
1930ES	3°	1.5°	18.75 ft (5.7 m)
		2°	14 ft (4.3 m)
		2.5°	11 ft (3.4 m)
		3°	9 ft (2.7 m)
2030ES	3°	1.5°	20 ft (6 m)
		2°	15 ft (4.5 m)
		2.5°	12 ft (3.7 m)
		3°	10 ft (3 m)
2630ES	3°	1.5°	25.4 ft (7.7 m)
		2°	20 ft (6 m)
		2.5°	16 ft (4.9 m)
		3°	13 ft (4 m)
2646ES	3°	2°	26 ft (7.9 m)
		2.5°	22 ft (6.7 m)
		3°	20 ft (6 m)
3246ES	3°	2°	31.75 ft (9.7 m)
		2.5°	22 ft (6.7 m)
		3°	20 ft (6 m)

If the machine does not appear to track the lift cutout heights and no fault exists as described above, stow the machine and re calibrate the Elevation Sensor.

### 5.5 ELEVATION SENSOR CALIBRATION

#### NOTICE

**MACHINE MUST BE ON LEVEL GROUND BEFORE ELEVATION SENSOR CAN BE SET.**

1. Be sure that the machine is parked and stowed on level ground.
2. Attach the analyzer near the ground control station.
3. Go to Access Level 1 and scroll through to CALIBRATION.
4. Under Calibrations, go to SET ELEV SENSOR.
5. Press enter for Yes and the Elevation Sensor will set.

**NOTE:** Check the elevation sensor by lifting the scissor arms, from the platform, and driving until the drive speed cuts back. Refer to Table 1-13, High Drive Speed Cut-out Height for proper speed cut out height.

### 5.6 UPDATING SOFTWARE

Updating the ground module software requires a laptop computer, connecting cable, and software update cd. Contact JLG Industries to acquire the software cd.

Before updating the software, use the Hand-held Analyzer to view the machine's settings (MACHINE SETUP and PERSONALITIES) (refer to Figure 5-2. thru Figure 5-4. for Analyzer Flow Chart). It is important to write down the settings to verify they are the same after software update is complete.

**NOTE:** Software update must be done with the machine powered in Ground Mode.

1. Disconnect analyzer from diagnostic port.
2. Using the laptop connector cable, connect the laptop to the diagnostic port.
3. Run the software update cd.
  - a. When the JLG Reprogramming Tool dialogue box appears, click on the Program button.
  - b. Another dialogue box will appear asking if you want to overwrite the current software version. Click YES.
4. After software update is complete, disconnect computer from diagnostic port.
5. Reconnect the hand-held analyzer to the diagnostic port.
  - a. Enter Access Level 1 password; 33271
  - b. Scroll to MACHINE SETUP. Change MODEL NUMBER to a different model, but immediately change it back to the proper setting. Do the same for MARKET. This will ensure the settings are carried over to all parameters.
  - c. Scroll through the settings to verify they are the same as before the software update.
6. Disconnect Analyzer.
7. Software update is complete.



## 5.7 TROUBLESHOOTING

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.

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.

**NOTE:** *It may also be helpful to do the following for intermittent or difficult problems: run a system test, ANALYZER -> SYSTEM TEST; check the machine personalities, ANALYZER ->PERSONALITIES (refer to Table 5-3, Machine Model Adjustment (Machines with Sevcon - 1600346 Power Module Only)); and check the machine setup, ANALYZER -> MACHINE SETUP (refer to Table 5-5, Machine Configuration Programming Information (Machines with Sevcon - 1600346 Power Module Only)).*

*These below flash codes apply only to machines without the MDI (refer to Section 3.2, MDI (Multifunction Digital Indicator) and brake release). For machines with the MDI, refer to Section 6, Diagnostic Trouble Codes.*

*Anytime a problem is resolved, recycle the EMS.*

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
<b>Help Messages with no flash code may occur during normal operation and explain various vehicle interlocks.</b>			
0 0	ALARM SOUNDING--TILTED AND ABOVE ELEVATION	Platform is elevated and the chassis is not level. Platform Position Sensor (PPS) elevation status is elevated and the vehicle is tilted and machine setup's TILT CUTOUT is 0=YES. No motion restrictions.	
0 0	DRIVING AT CUTBACK -- ABOVE ELEVATION	Platform is elevated and the machine is in the drive mode of operation. In platform mode, Platform Position Sensor (PPS) elevation status is elevated and the vehicle is driving and the drive speed is drive elevated. Driving at elevated speed.	
0 0	DRIVE & LIFT UP PREVENTED -- TILTED & ELEVATED	Driving is not possible since the platform is elevated and the chassis is not level. In Platform Mode, Platform Position Sensor (PPS) elevation status is elevated and the vehicle is tilted and machine setup's TILT CUTOUT is 1=YES. Drive prevented.	
0 0	LIFT UP PREVENTED -- MAX HEIGHT ZONE A	Applicable to 3246ES configured for the Zone A/B Capacity Selection, and operating on Zone A. The vehicle has reached the maximum height and further lift up motion is not possible. Machine Setup's CAPACITY SELECT is 1=ZONE A/B and Machine Setup's MODEL is 3246ES and Zone A Lift Up=False. Lift up prevented.	

## SECTION 5 - JLG CONTROL SYSTEM

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
0 0	DRIVING AT CUTBACK -- POTHOLE STILL ENGAGED	While stowed, drive speed is reduced (due to lower ground clearance) since the control system detected that the pot-hole protection mechanism is deployed (failed to retract). In platform mode with a healthy elevation sensor, elevation sensor less than 0.15V and the elevation prox closed and pot-hole protection's PHP switches detect down. In platform mode with an unhealthy elevation sensor, the elevation prox is closed <u>AND</u> pot-hole protection's PHP switches detect down.	Clear the obstacle blocking the pot-hole protection mechanism, repair the mechanical problem, re-adjust the pot-hole limit switches, or repair the wiring to correct the problem.
0 0	FUNCTIONS LOCKED OUT -- SYSTEM POWER DOWN	After 2 hours without activity, the control system enters a low-power state to preserve battery charge.	Check batteries charge, condition, etc. Normal operation should resume after a power cycle.
0 0	DRIVE PREVENTED -- ELEVATED AND ABOVE DRIVE CUT-OUT HEIGHT	The Drive Cutout functionality is enabled, and the platform is elevated above the calibrated cutout height. Drive Cutout is set to 1= YES <u>AND</u> the Elevation Sensor is "Healthy" <u>AND</u> the Elevation Sensor's Zeroed Voltage is Greater Than the Calibrated Drive Cutout Voltage. Refer to Drive Cutout Functionality.	Check elevation switches Check pothole switches.
<b>Help messages with the 2-1 flash code occur during after power-up of the vehicle control system.</b>			
2 1	STARTUP	This help message is issued at each power-up. This serves to indicate which messages have been recorded in logged help since the last power-up event. No motion restrictions. No motions restricted.	
2 1	KEYSWITCH FAULTY -- PLATFORM & GROUND ACTIVE TOGETHER	The platform and ground mode inputs from the keyswitch are active at the same time. The control system will default to ground mode when if this happens. The keyswitch and wiring inside the ground control box should be examined / repaired. Platform EMS digital input energized and ground mode select digital input energized. Default to ground mode operation and lift up prevented	Re-cycle power once the problem has been resolved to clear this difficulty.
<b>Help messages with the 2-2 flash code indicate difficulty with the platforms controls.</b>			
2 2	FUNCTION PROBLEM -- HORN PERMANENTLY SELECTED	Horn switch in the platform control box was closed during power-up. In platform mode, the Indoor/Outdoor switch digital input is energized and power-up is active. Retained until either is momentarily de-energized. Previously selected Indoor/Outdoor mode maintained.	Release or repair the switch to clear the message.
2 2	FUNCTION PROBLEM -- INDOOR / OUTDOOR PERMANENTLY SELECTED	Indoor / Outdoor switch in the platform control box was closed during power-up. In Platform Mode, the Indoor / Outdoor Switch Digital Input is Energized and Power-up is Active. Retained until Digital Input is momentarily De-energized. Previously selected Indoor / Outdoor Mode maintained	Release or repair the switch to clear the message.

Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
2 2	FUNCTION PROBLEM -- DRIVE & LIFT ACTIVE TOGETHER	The Drive - Lift selector switch indicates that both functions are selected simultaneously. In Platform Mode, the Drive and Lift Digital Inputs are Energized at the same time. Retained until either is momentarily De-energized. Drive, Steer, & Lift Prevented	Repair the wiring or switch to clear the message.
2 2	FUNCTION PROBLEM -- STEER LEFT PERMANENTLY SELECTED	Steer left switch in the platform control box was closed during power-up. In Platform Mode, the Left Steer Digital Input Switch is Energized AND Power-up is Active. Retained until Digital Input is momentarily De-energized. Steer & Drive Prevented	Release or repair the switch to clear the message.
2 2	FUNCTION PROBLEM -- STEER RIGHT PERMANENTLY SELECTED	Steer right switch in the platform control box was closed during power-up. In Platform Mode, the Right Steer Digital Input Switch is Energized and Power-up is Active. Retained until Digital Input is momentarily De-energized. Steer & Drive Prevented.	Release or repair the switch to clear the message.
2 2	ACCELERATOR FAULTY -- WIPER OUT OF RANGE	The joystick (accelerator) wiper signal input is outside the acceptable voltage range. In Platform Mode, the Joystick (accelerator) Analog Input Switch is $> 4.50V$ OR $< 0.50V$ . Retained until Analog Input is measured within proper range. Drive, Steer, & Lift Prevented.	The wiper wire being off, the wiper wire shorted to +B, or the wiper wire shorted to -B (ground) could cause this difficulty.
2 2	ACCELERATOR FAULTY -- STEER SWITCHES ACTIVE TOGETHER	Both the steer left and steer right inputs are closed as the same time. In Platform Mode, the Steer Left Digital Input is Energized and the Steer Right Digital Input is Energized. Retained until either Digital Input is momentarily De-energized. Drive & Steer Prevented.	A short in the steer switch wiring or a failed steer switch can cause this difficulty.
2 2	FUNCTION LOCKED OUT -- ACCELERATOR NOT CENTERED	Selected function (drive or lift) is not allowed because the joystick (accelerator) was not centered at power-up. In Platform Mode, scaled Joystick (accelerator) position was something other than 0% AND Power-up was Active. Retained until the Joystick is momentarily centered. Drive, Steer, & Lift Prevented.	Return joystick to center momentarily and re-initiate.
2 2	FUNCTION PROBLEM -- TRIGGER PERMANENTLY CLOSED	Trigger switch in the platform control box was closed at power-up. In Platform Mode, the Trigger Digital Input was Energized AND Power-up was Active. Retained until the Trigger Digital Input is momentarily De-energized. Drive, Steer, & Lift Prevented.	Release switch or repair the switch / wiring to clear the difficulty.
2 2	TRIGGER CLOSED TOO LONG WHILE IN NEUTRAL	Trigger switch in the platform control box was closed for more than ten seconds while the joystick (accelerator) was in the neutral position (centered). In Platform Mode, the Trigger Digital Input was Energized for 10,000mS AND Drive was In-Active AND Lift was In-Active. Retained until the Trigger Digital Input is momentarily De-energized. Drive, Steer, & Lift Prevented.	Release switch or repair the switch / wiring to clear the difficulty.

## SECTION 5 - JLG CONTROL SYSTEM

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
<b>Help messages with the 2-3 flash code indicate difficulty with the ground controls.</b>			
2 3	FUNCTION PROBLEM – LIFT PERMANENTLY SELECTED	Lift switch (up or down) in the ground control box was closed during power-up. In Ground Mode, [Lift Up Digital Input is Energized or Lift Down Digital Input is Energized] AND Power-up is Active. Retained until the respective Digital Input is momentarily De-energized. Lift Prevented	Release or repair the switch to clear the message.
2 3	GROUND LIFT UP/DOWN ACTIVE TOGETHER	In ground mode, the control system has detected the lift up and down are active simultaneously. In Ground Mode, Ground Lift Up Digital Input is Energized and Ground Lift Down Digital Input is Energized. Retained until both the Digital Inputs are momentarily De-energized. Lift Prevented	Check the lift switch and associated wiring in the ground control box.
2 3	NO DATA FROM TILT SENSOR – NOT CONNECTED OR FAULTY	No signal from the tilt sensor mounted inside the ground control box. Transitions on the Tilt X OR Tilt Y signals not detected for 2000mS. Retained until transitions on both are sensed. Vehicle assumed Tilted (+20.0° X, +20.0° Y); Drive Stowed Demand limited as in Worst-Case Slope Descent Functionality for both Forward and Reverse Drive will be slow in the Forward direction.	Check wiring and plug connections at the tilt sensor and at the ground control board.
2 3	TILT SENSOR NOT CALIBRATED	The Tilt Sensor's Calibration EEPROM is set to the signature implanted by the In-Circuit Test Fixture. Retained until Calibration EEPROM is over-written by a valid calibration. Vehicle assumed Tilted (+20.0° X, +20.0° Y); Drive Stowed Demand limited as in Worst-Case Slope Descent Functionality for both Forward and Reverse Drive will be slow in the forward direction.	Calibrate the Tilt Sensor using the calibration procedure to clear the message.
2 3	FUNCTION PROBLEM -- BRAKE RELEASE PERMANENTLY SELECTED	The ground control box lift switch was closed up or down, during power-up in ground mode.	Check if the lift switch is obstructed or jammed. Check the lift switch signal and wiring to the ground board. Replace ground board.
<b>Help messages with the 2-5 flash code indicate that a function is prevented due to a cutout.</b>			
2 5	ELEV ANGLE SENSOR FAULTY – NOT MOUNTED OR VOLTAGE OUT OF RANGE	The input voltage from the sensor that measures lower arm motion is outside acceptable range. This may be caused by improper sensor mounting, difficulty with the sensor wiring, or a faulty sensor. The elevation sensor is unhealthy Platform height assumed to be full elevation.	Check mounting, review sensor wiring against the electrical schematic, or replace the sensor to clear the message.

Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
2 5	ELEV ANGLE SENSOR HAS NOT BEEN CALIBRATED	The Elevation Sensor's Calibration EEPROM is set to the signature implanted by the In-Circuit Test Fixture. Retained until Calibration EEPROM is over-written by a valid calibration. Platform Height assumed to be Full Elevation. The Elevation Proximity Switch is Open to indicate that the Platform is Elevated, but the Elevation Sensor's Voltage indicates that the Platform is Stowed. To be conservative, the control system will assume that the Platform is Elevated. Elevation Sensor is "Healthy" AND the Elevation Sensor's Zeroed Voltage is < 0.04V AND the Elevation Prox Switch is Open for 2000mS. Retained until situation changes.	Calibrate the elevation angle sensor using the calibration procedure to clear the message.
2 5	DRIVE PREVENTED – CHARGER CONNECTED	Driving is not possible since the vehicle is charging and it is configured to only allow lifting. In Platform Mode, the Battery Charger is Charging AND the Drive / Lift Select Toggle is set to Lift AND Machine Setup's CHARGE INTERLOC is set to 0=DRIVE ONLY. Drive & Steer Prevented	Disconnect battery charger
2 5	DRIVE & LIFT UP PREVENTED – CHARGER CONNECTED	Driving and lifting are not possible since the vehicle is charging and it is configured to prevent all motion. In Platform Mode, the Battery Charger is Charging AND the Drive / Lift Select Toggle is set to Lift AND Machine Setup's CHARGE INTERLOC is set to 1=DRV & LIFT UP. Drive & Lift Up Prevented.	Disconnect battery charger
2 5	PLATFORM OVERLOADED	While the Load Sensing System is enabled, the platform load measured by the Load Sensing System is excessive. Functions from platform control are prevented, and functions from ground control may be prevented, depending on machine configuration. The Load Sensing System Functionality's Overload is True AND [Machine Setup's LOAD is set to 1=CUTOUT PLT OR 2=CUTOUT ALL]. Drive, Steer, & Lift Prevented (except 3246ES CE, Indoor Mode, Height >24 Ft and < 26Ft, Lift Dn allowed).	Remove excess weight from platform.
2 5	DRIVE PREVENTED – POT HOLE NOT ENGAGED	While elevated, driving is not possible since the control system detected that the pot-hole protection mechanism failed to deploy. In Platform Mode with a Healthy Elevation Sensor, the Elevation Sensor Voltage > 0.15V AND Pot-Hole Protection's PHP Switches detect Up. In Platform Mode with an Unhealthy Elevation Sensor, the Elevation Prox Sensor is Open (no Arm Detected) AND Pot-Hole Protection's PHP Switches detect Up. Drive & Steer Prevented.	Clear the obstacle blocking the pot-hole protection mechanism, repair the mechanical problem, re-adjust the pot-hole limit switches, or repair the wiring to correct the problem.

## SECTION 5 - JLG CONTROL SYSTEM

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
2 5	ELEV PROX PERMANENTLY CLOSED – CHECK PROX AND ANGLE ADJUSTMENT	The Elevation Proximity Switch is closed to indicate that the platform is stowed, but the elevation sensor's voltage indicates that the platform is elevated. To be conservative, the control system will assume that the platform is elevated, and the drive speed will be restricted to elevated. Elevation Sensor is "Healthy" <u>AND</u> the Elevation Sensor's Zeroed Voltage is > 0.15V <u>AND</u> the Elevation Prox Switch is Closed for 2000mS. Retained until situation changes. Refer to Platform Position Sensor Functionality.	Check elevation switches. Replace if necessary.
2 5	DRIVE & LIFT PREVENTED – BRAKES ELECTRICALLY RELEASED FOR TOWING	The manual brake release has been activated to allow the vehicle to be towed. Brake release digital input is energized Drive and Lift Prevented	Disengage the manual brake release.
2 5	DRIVE PREVENTED – ELEVATED ABOVE DRIVE CUTOUT HEIGHT	The Drive Cutout functionality is enabled, and the platform is elevated above the calibrated cutout height. Drive Cutout is set to 1=YES <u>AND</u> the Elevation Sensor is "Healthy" <u>AND</u> the Elevation Sensor's Zeroed Voltage is Greater Than the Calibrated Drive Cutout Voltage. Refer to Drive Cutout Functionality.	Check elevation switches Check pothole switches.
2 5	MODEL CHANGED -- HYDRAULICS SUSPENDED - CYCLE EMS	The model selection has been changed.	Check ANALYZER -> MACHINE SETUP -> MODEL NUMBER. Replace ground board.
2 5	DRIVE PREVENTED -- BRAKES NOT RELEASING	While driving on a level surface, armature current was > 150A for five seconds. Brakes assumed to not be releasing properly.	Ensure vehicle is not stuck on something preventing movement. Check/repair drive motor wiring, brakes or mechanical issues.
<b>Help messages with the 3-1 flash code indicate that a contactor did not close when energized.</b>			
3 1	OPEN CIRCUIT LINE CONTACTOR	The Power Module's line contactor drive circuitry passed power-up self-tests, but the line contactor did not close when energized. The Power Module is reporting a "Contactor Did Not Close" Fault Code (15d). Drive, Steer, & Lift Up Prevented.	Refer to CANbus documentation for Power Module Message - Status.
3 1	CONTACTOR DRIVER PERMANENTLY OFF	The Power Module's Line Contactor drive circuitry failed to energize during power-up self-tests. The Power Module is reporting a "Contactor Driver 1 Permanently Off" Fault Code (22d). Drive, Steer, & Lift Up Prevented.	Refer to CANbus documentation for Power Module Message - Status.
<b>Help messages with the 3-2 flash code indicate that a contactor did not open when de-energized.</b>			
3 2	LINE CONTACTOR MISWIRED ON OR WELDED	The Power Module's Line Contactor Drive Circuitry passed power-up self-tests, but the line contactor did not open when de-energized. The Power Module is reporting a "Contactor Welded" Fault Code (14d). Drive, Steer, & Lift Up Prevented.	Refer to CANbus documentation for Power Module Message - Status.

Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
3 2	CONTACTOR DRIVER PERMANENTLY ON	The Power Module's Line Contactor Drive Circuitry failed to de-energize during power-up self-tests. The Power Module is reporting a "Contactor Driver 1 Permanently On" Fault Code (23d). Refer to CANbus documentation for Power Module Message – Status. Drive, Steer, & Lift Up Prevented.	Refer to CANbus documentation for Power Module Message – Status.
<b>Help messages with the 3-3 flash code indicate an output driver problem.</b>			
<b>NOTE: Certain output driver problems cannot be detected because stimulation of the load could result in safety concerns or annoyance (brake open circuit, lift down open circuit, ground alarm open circuit). 3-3 help messages shall be latched until the next power cycle.</b>			
3 3	BRAKE SHORT TO BATTERY	Voltage was detected on the brake solenoid when the output driver was commanded off during power-up. Brake INPUT driven Low <u>AND</u> Brake STAT detected Low during power-up. Drive, Steer, & Lift Prevented.	
3 3	BRAKE OPEN CIRCUIT	Current flow to the brake solenoid was not detected during normal brake operation. Brake INPUT driven High (normal operation) <u>AND</u> Brake STAT detected Low. Drive & Steer Prevented	
3 3	LIFT UP SHORT TO BATTERY	Voltage was detected on the lift up solenoid when the output driver was commanded off during power-up. Lift Up INPUT driven Low <u>AND</u> Lift Up STAT detected Low during power-up. Drive, Steer, & Lift Up Prevented.	
3 3	LIFT UP OPEN CIRCUIT	Current flow to the lift up solenoid was not detected during power-up. Lift Up INPUT driven High (momentarily) <u>AND</u> Lift Up STAT detected Low during power-up. No motion interlocks.	
3 3	LIFT DN SHORT TO BATTERY	Voltage was detected on the lift down solenoid when the output driver was commanded off during power-up. Lift Down INPUT driven Low <u>AND</u> Lift Down STAT detected Low during power-up. No motion interlocks.	
3 3	LIFT DN OPEN CIRCUIT	Current flow to the lift down solenoid was not detected during normal lift down motion. Lift Down INPUT driven High (normal operation) <u>AND</u> Lift Down STAT detected Low. Lift Up Prevented.	
3 3	STEER LEFT SHORT TO BATTERY	Voltage was detected on the steer left solenoid when the output driver was commanded off during power-up. Left Turn INPUT driven Low <u>AND</u> Left Turn STAT detected Low during power-up. Drive & Steer Prevented.	

## SECTION 5 - JLG CONTROL SYSTEM

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
3 3	STEER LEFT OPEN CIRCUIT	Current flow to the steer left solenoid was not detected during power-up. Left Turn INPUT driven High (momentarily) <u>AND</u> Left Turn STAT detected Low during power-up. Drive & Steer Prevented.	
3 3	STEER RIGHT SHORT TO BATTERY	Voltage was detected on the steer right solenoid when the output driver was commanded off during power-up. Right Turn INPUT driven Low <u>AND</u> Right Turn STAT detected Low during power-up. Drive & Steer Prevented.	
3 3	STEER RIGHT OPEN CIRCUIT	Current flow to the steer right solenoid was not detected during power-up. Right Turn INPUT driven High (momentarily) <u>AND</u> Right Turn STAT detected Low during power-up. Drive & Steer Prevented.	
3 3	GROUND OVERLOAD LAMP SHORT TO BATTERY	While the load sensing system was enabled, voltage was detected on the ground control box's overload lamp when the output driver was commanded off during power-up. Ground Overload INPUT driven Low <u>AND</u> Ground Overload STAT detected Low during power-up <u>AND</u> [Machine Setup's LOAD set to 1=CUTOOUT PLT <u>OR</u> 2=CUTOOUT ALL]. No motion interlocks.	
3 3	GROUND OVERLOAD LAMP OPEN CIRCUIT	While the Load Sensing System was enabled, current flow to the ground control box's overload lamp was not detected during power-up. Ground Overload INPUT driven High (momentarily) <u>AND</u> Ground Overload STAT detected Low during power-up <u>AND</u> [Machine Setup's LOAD set to 1=CUTOOUT PLT <u>OR</u> 2=CUTOOUT ALL]. No motion interlocks.	
3 3	GROUND ALARM SHORT TO BATTERY	While enabled, voltage was detected on the ground alarm when the output driver was commanded off during power-up. Ground Alarm INPUT driven Low <u>AND</u> Ground Alarm STAT detected Low during power-up <u>AND</u> [Machine Setup's GROUND ALARM set to 1=DECENT <u>OR</u> 2=MOTION]. No motion interlocks.	
3 3	LEFT BRAKE SHORT TO BATTERY	The ground board detected voltage while the left brake was commanded off.	Check for continuity through this circuit. Inspect the wiring for physical damage. Replace ground board.
3 3	LEFT BRAKE OPEN CIRCUIT	Current flow to the left brake solenoid was not detected during normal left brake operation.	Check for continuity through this circuit. Inspect the wiring for physical damage. Replace ground board.
3 3	RIGHT BRAKE SHORT TO BATTERY	Voltage was detected on the right brake solenoid when the ground board output was commanded off during power-up.	Check for continuity through this circuit. Inspect the wiring for physical damage. Replace ground board.



Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
3 3	RIGHT BRAKE OPEN CIRCUIT	The ground board did not detect current flow to the right brake during normal operation.	Check for continuity through this circuit. Inspect the wiring for physical damage. Replace ground board.
<b>Help messages with the 4-2 flash code indicate a thermal problem.</b>			
4 2	POWER MODULE TOO HOT – PLEASE WAIT	The Power Module for drive, steer, and lift up has reached thermal cutout. Allow to cool by powering down. The power Module is reporting a "Unit Too Hot" fault code.	
4 2	DRIVING AT CUTBACK -- POWER MODULE CURRENT LIMIT	The drive portion of the Power Module has reached thermal limit. Allow to cool by waiting for temperature to fall. The Power Module is reporting a "I <sup>2</sup> T Drive Current Llimit" fault code.	
4 2	LIFT UP AT CUTBACK -- POWER MODULE CURRENT LIMIT	The lift up portion of the power module has reached thermal limit. Allow to cool by waiting for temperature to fall. The POver Module is reporting "I <sup>2</sup> Pump Current Llimit" fault code.	
<b>Help messages with the 4-4 flash code indicate a battery supply problem.</b>			
4 4	BATTERY VOLTAGE TOO LOW – SYSTEM SHUTDOWN	Battery Voltage momentarily dropped below 14.5V. With a low battery charge, this can occur during heavy current demand due to drive, steer, or lift up. The Power Module is reporting a "Low Battery" Fault Code (7d). Drive, Steer, & Lift Up Prevented	Recharge batteries or check for damaged batteries.
4 4	BATTERY VOLTAGE TOO HIGH – SYSTEM SHUTDOWN	The Power Module momentarily measured excessively high battery voltage (>37.0v) and the ground module de-energized the ignition relay to protect system devices. The Power Module is reporting a "High Battery" Fault Code (8d) OR a "High Battery without Line" Fault Code (10d). In response, the Ground Module shall de-energize the Ignition Relay and suppress all Help Messages caused by the lack of Ignition Signal. This fault is latched until the next power-cycle. Drive, Steer, & Lift Prevented.	This may be due to improper battery charging or incorrect voltage batteries being used.
4 4	LSS BATTERY VOLTAGE TOO HIGH	While the Load Sensing System is enabled, the Load Sensing System module measured battery voltage >34.0Vdc, which may compromise ability to predict weight. LSS Module Message – Status Message (0x81) is reporting "BATT TOO HIGH" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	This may be due to improper battery charging or incorrect voltage batteries being used.
4 4	LSS BATTERY VOLTAGE TOO LOW	While the Load Sensing System is enabled, the Load Sensing System module measured battery voltage <9.0vdc, which may compromise ability to predict weight. With a low battery charge, this can occur during heavy current demand due to drive, steer, or lift up. LSS Module Message – Status Message (0x81) is reporting "BATT TOO LOW" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	Recharge batteries or check for damaged batteries.

## SECTION 5 - JLG CONTROL SYSTEM

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
<b>Help messages with the 6-6 flash code indicate vehicle communication (CANbus) problems. These faults shall not be latched. Normal operation shall resume if difficulty is resolved.</b>			
6 6	CANBUS FAILURE: POWER MODULE	The control system failed to receive messages from the Power Module. Power Module Message – Status (0x24) not received for 1000mS or Power Module is reported a “CANbus Bus Difficulty” Fault Code (0x09). Drive, Steer, & Lift Up Prevented.	Check wiring at the ground control box and power module. Recycle power to clear difficulty.
6 6	CANBUS FAILURE: PLATFORM MODULE	In Platform Mode, the control system failed to receive messages from the platform module. Digital Input Message – Motion (0x00) not received for 1000mS AND Platform Mode selected. Retained until power is re-cycled. All Platform functions Prevented. Normal operation from Ground Mode.	Check wiring at the platform and ground control boxes. Check wiring along scissor arms leading up to Platform.
6 6	CANBUS FAILURE: LOAD SENSING SYSTEM MODULE	With the Load Sensing System enabled, the control system failed to receive messages from the Load Sensing System Module. LSS Module Message – Load Cell Message (0x80) not received for 1000mS AND [Machine Setup’s LOAD set to 1=CUTOUT PLT QR 2=CUTOUT ALL]. Retained until power is re-cycled. Vehicle assumed to be Overloaded.	Check wiring at the Load Sensing System Module and along scissor arms leading up to platform.
6 6	ACCESSORY CAN COMMUNICATION LOST	A JLG Accessory Module has failed to maintain CANbus communications with the ground module. The control system received Accessory Message – Control 1 from an Accessory Module, but failed to receive another within 1000mS. Retained until power is re-cycled. No motion interlocks.	Refer to documentation for the JLG Accessory to clear difficulty.
<b>Help messages with the 6-7 flash code indicate JLG accessory problems. These faults shall not be latched. Normal operation shall resume if difficulty is resolved.</b>			
6 7	ACCESSORY FAULT	A JLG Accessory Module has encountered a fault condition and reported it via the host control system. Accessory Message – Control 1’s Request Accessory Fault flag is set to YES. Retained or cleared based on status of flag. No motion interlocks.	Refer to documentation for the JLG Accessory to clear difficulty.
<b>Help messages with the 7-7 flash code indicate motor problems.</b>			
7 7	OPEN-CIRCUIT DRIVE MOTOR FIELD WIRING	The Power Module detected an error in the power wiring (F1 & F2 Terminals) for the drive motors. The Power Module is reporting a “Field Open Circuit” Fault Code (16d). Retained until power is re-cycled. Drive & Steer Prevented	Check power wiring and re-cycle power to clear difficulty.
<b>Help messages with the 8-x flash codes indicate problems with the platform load sensing system. The second digit of the flash code is used to indicated channel.</b>			
8 1	LSS CELL #1 ERROR	Cell #1’s Bridge <2Vdc, >3Vdc, or could the LSS Module could not read Cell #1’s Internal Memory. 8-1 Flash Code LSS Module Message – Status Message (0x81) is reporting “CELL 1 ERROR” AND [Machine Setup’s LOAD is set to 1=CUT-OUT PLT QR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	This situation indicates that the sensor is unplugged, or the sensor is damaged.

Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
8 2	LSS CELL #2 ERROR	Cell #2's Bridge <2Vdc, >3Vdc, or could the LSS Module could not read Cell #2's Internal Memory. 8-2 Flash Code LSS Module Message – Status Message (0x81) is reporting "CELL 2 ERROR" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	This situation indicates that the sensor is unplugged, or the sensor is damaged.
8 3	LSS CELL #3 ERROR	Cell #3's Bridge <2Vdc, >3Vdc, or could the LSS Module could not read Cell #3's Internal Memory. 8-3 Flash Code LSS Module Message – Status Message (0x81) is reporting "CELL 3 ERROR" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	This situation indicates that the sensor is unplugged, or the sensor is damaged.
8 4	LSS CELL #4 ERROR	Cell #4's Bridge <2Vdc, >3Vdc, or could the LSS Module could not read Cell #4's Internal Memory. 8-4 Flash Code LSS Module Message – Status Message (0x81) is reporting "CELL 4 ERROR" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Vehicle assumed to be Overloaded.	This situation indicates that the sensor is unplugged, or the sensor is damaged.
<b>Help messages with the 9-x flash codes indicate controller (module) problems. The second digit of the flash code provides additional information about the difficulty.</b>			
9 1	LSS WATCHDOG RESET	The Watchdog Timer on Load Sensing System Module's micro-processor was triggered by exposure to excessive electrical noise, or by a hardware difficulty. 9-1 Flash Code LSS Module Message – Status Message (0x81) is reporting "WATCHDOG RST" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Retained until power is re-cycled. No motion interlocks.	Re-cycle power to clear difficulty
9 2	LSS EEPROM ERROR	Memory used to retain settings on Load Sensing System Module has been corrupted and must be reset by verifying all entries / re-calibrating. 9-2 Flash Code LSS Module Message – Status Message (0x81) is reporting "EEPROM ERROR" AND [Machine Setup's LOAD is set to 1=CUT-OUT PLT OR 2=CUTOUT ALL]. Retained until power is re-cycled. Vehicle assumed to be Overloaded	After resolution, re-cycle power to clear difficulty.
9 3	LSS HAS NOT BEEN CALIBRATED	9-3 Flash Code The Load Sensing System's Calibration EEPROM for Empty Platform Load is set to Never Set (signature implanted by the In-Circuit Test Fixture) AND [Machine Setup's LOAD is set to 1=CUTOUT PLT OR 2=CUTOUT ALL]. Retained until Calibration EEPROM is over-written by a valid calibration. Vehicle assumed to be Overloaded.	Calibrate the Load Sensing System using the calibration procedure to clear the message.

**Table 5-2. Flash Code Listing**

Flash Code	Help Message	Cause	Possible Resolve
9 9	LSS INTERNAL ERROR – PIN EXCITATION	The Excitation Voltage for the Load Sensors < 4.25V. 9-9 Flash Code LSS Module Message – Status Message (0x81) is reporting “INTERNAL ERROR – PIN EXCITATION < 4.25V” AND [Machine Setup’s LOAD is set to 1=CUTOUT PLT OR 2=CUTOUT ALL]. Retained until power is re-cycled. Vehicle assumed to be Overloaded.	The sensors may be excessively loading the Excitation Supply due to wiring damage, or the Load Sensing System Module may have hardware difficulty.
9 9	LSS INTERNAL ERROR – DRDY MISSING FROM A/D	The DRDY Interrupt from the Load Sensing System Module’s A/D Converter is missing. 9-9 Flash Code LSS Module Message – Status Message (0x81) is reporting “INTERNAL ERROR – DRDY INTERRUPT FROM A/D” AND [Machine Setup’s LOAD is set to 1=CUTOUT PLT OR 2=CUTOUT ALL]. Retained until power is re-cycled. Vehicle assumed to be Overloaded.	This may indicate Load Sensing System Module hardware difficulty.
9 9	POWER MODULE FAILURE: PERSONALITY RANGE ERROR	The Power Module detected an out-of-range or corrupt personality setting. 9-9 Flash Code The Power Module is reporting a “Configuration Range” Fault Code (11d) OR a “Configuration CRC” Fault Code (12d) OR a “Motor Setup” Fault Code (13d). Retained until power is re-cycled.	Reset control system Personalities to default settings to clear difficulty.
9 9	POWER MODULE FAILURE: INTERNAL ERROR	The Power Module detected an internal error via self-test. 9-9 Flash Code The Power Module is reporting a “Two Direction” Fault Code (4d) OR a “Sequence” Fault Code (5d) OR a “CANbus Input” Fault Code (6d) OR a “12V Supply Detection” Fault Code (18d) OR a “System Monitor Activated” Fault Code (24d). Retained until power is re-cycled.	Re-cycle power to clear difficulty.
9 9	POWER MODULE FAILURE: CHECK POWER CIRCUITS OR MOSFET SHORT CIRCUIT	The Power Module detected an error in the Power Wiring for the Drive or Pump. Alternately, the Power Module has failed a self-test. 9-9 Flash Code The Power Module is reporting an “Armature MOSFET Short Circuit” Fault Code (17d) OR an “Armature MOSFET’s Off” Fault Code (19d) OR an “Armature MOSFET’s On” Fault Code (20d) OR an “Armature Pullup MOSFET Short Circuit” Fault Code (21d). Retained until power is re-cycled.	Check wiring and motors or replace the Power Module. Re-cycle power to clear difficulty.
9 9	POWER MODULE FAILURE: SYSTEM MONITOR	The ground board detected armature, field, or pump current while function was not commanded.	Refer to Drive Motor Electrical Evaluation in Section 3.7. Refer to Pump Motor Electrical Evaluation in Section 4.7. Refer to Power Module Electrical Evaluation in Section 3.8.
9 9	EEPROM FAILURE – CHECK ALL SETTINGS	The control system detected an EEPROM failure. Personalities and Machine Setup settings may be reset to default values. 9-9 Flash Code The control system’s EEPROM checksum indicates corruption. Retained until EEPROM settings are corrected and power is re-cycled.	Check / correct all settings and re-cycle power to clear difficulty.

Table 5-2. Flash Code Listing

Flash Code	Help Message	Cause	Possible Resolve
9 9	FUNCTIONS LOCKED OUT – MACHINE NOT CONFIGURED	The control system has not been configured for the first time. 9-9 Flash Code The control system's EEPROM flag indicates that the vehicle has not been configured (new control system components). Retained until EEPROM flag is cleared and power is re-cycled.	Use the JLG Analyzer to adjust all Machine Setup and Personality settings and re-cycle power to clear difficulty.
9 9	FUNCTIONS LOCKED OUT – PLATFORM MODULE SOFTWARE VERSION IMPROPER	The control system will not function because the Platform Module Software Version is not compatible with the rest of the system. 9-9 Flash Code The Platform Module reported a Software Major Version that was not equal to "1". The control system may resume operation once the difficulty has been corrected.	Re-program or replace with a Version 1.xx module.
9 9	FUNCTIONS LOCKED OUT – POWER MODULE SOFTWARE VERSION IMPROPER	The control system will not function because the Power Module Software Version is not compatible with the rest of the system. 9-9 Flash Code The Power Module reported a Software Major Version that was not equal to "1". The control system may resume operation once the difficulty has been corrected.	Re-program or replace with a Version 1.xx module.
9 9	FUNCTIONS LOCKED OUT – LSS MODULE SOFTWARE VERSION IMPROPER	The control system will not function because the LSS Module Software Version is not compatible with the rest of the system. 9-9 Flash Code Machine Setup's LOAD=1 or 2 AND the LSS Module reported a Software Major Version that was not equal to "7". The control system may resume operation once the difficulty has been corrected.	Re-program or replace with a Version 7.xx module.

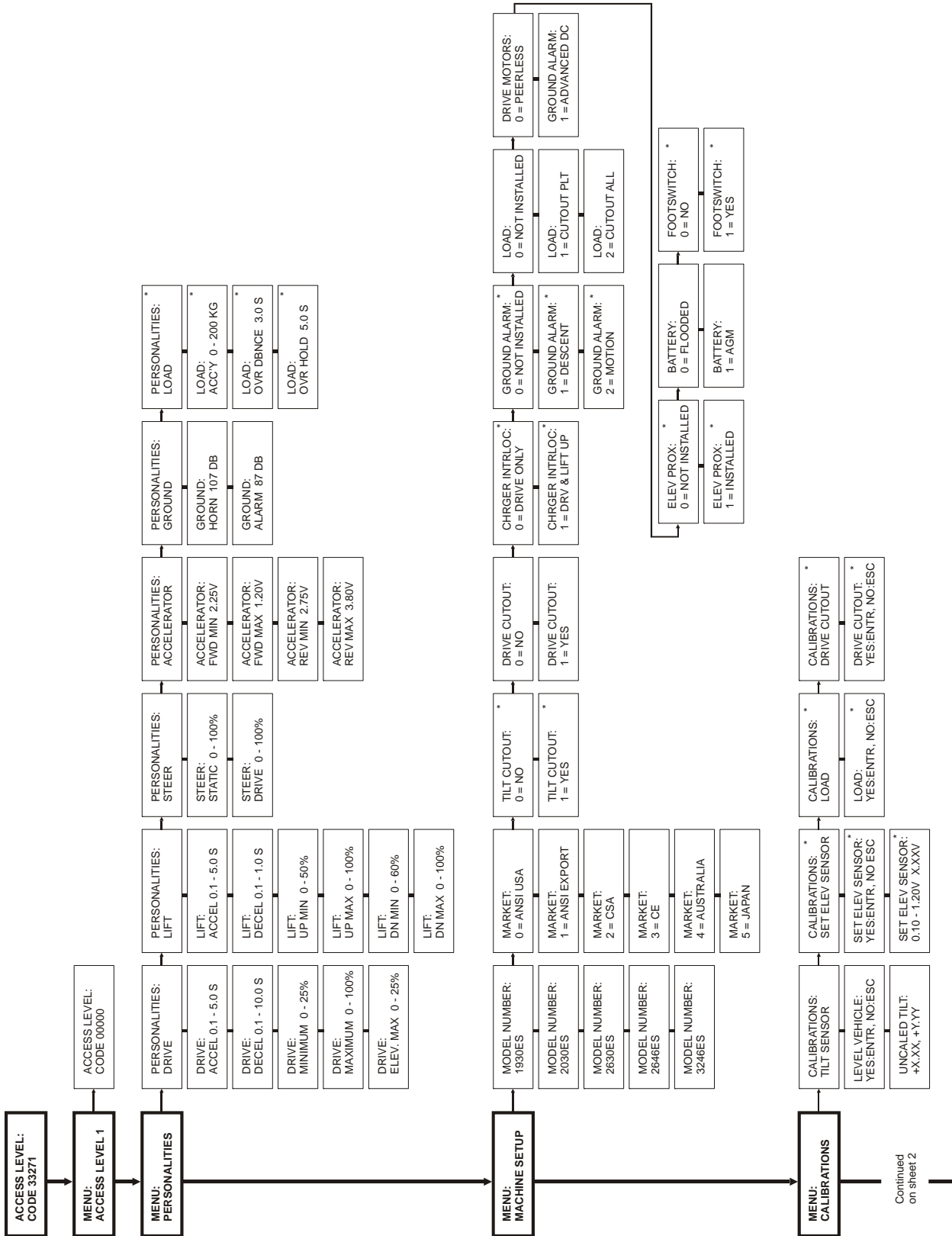
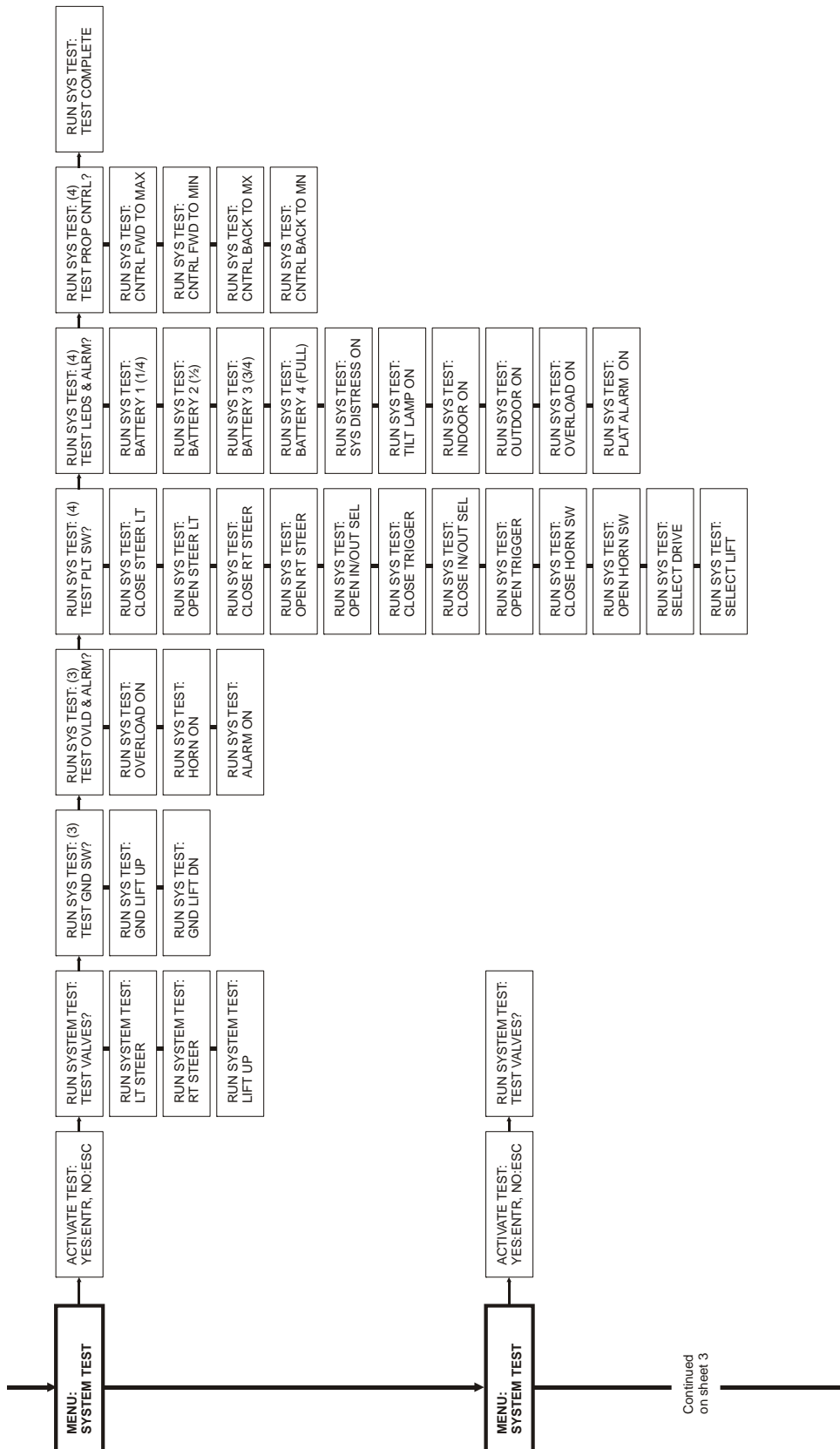
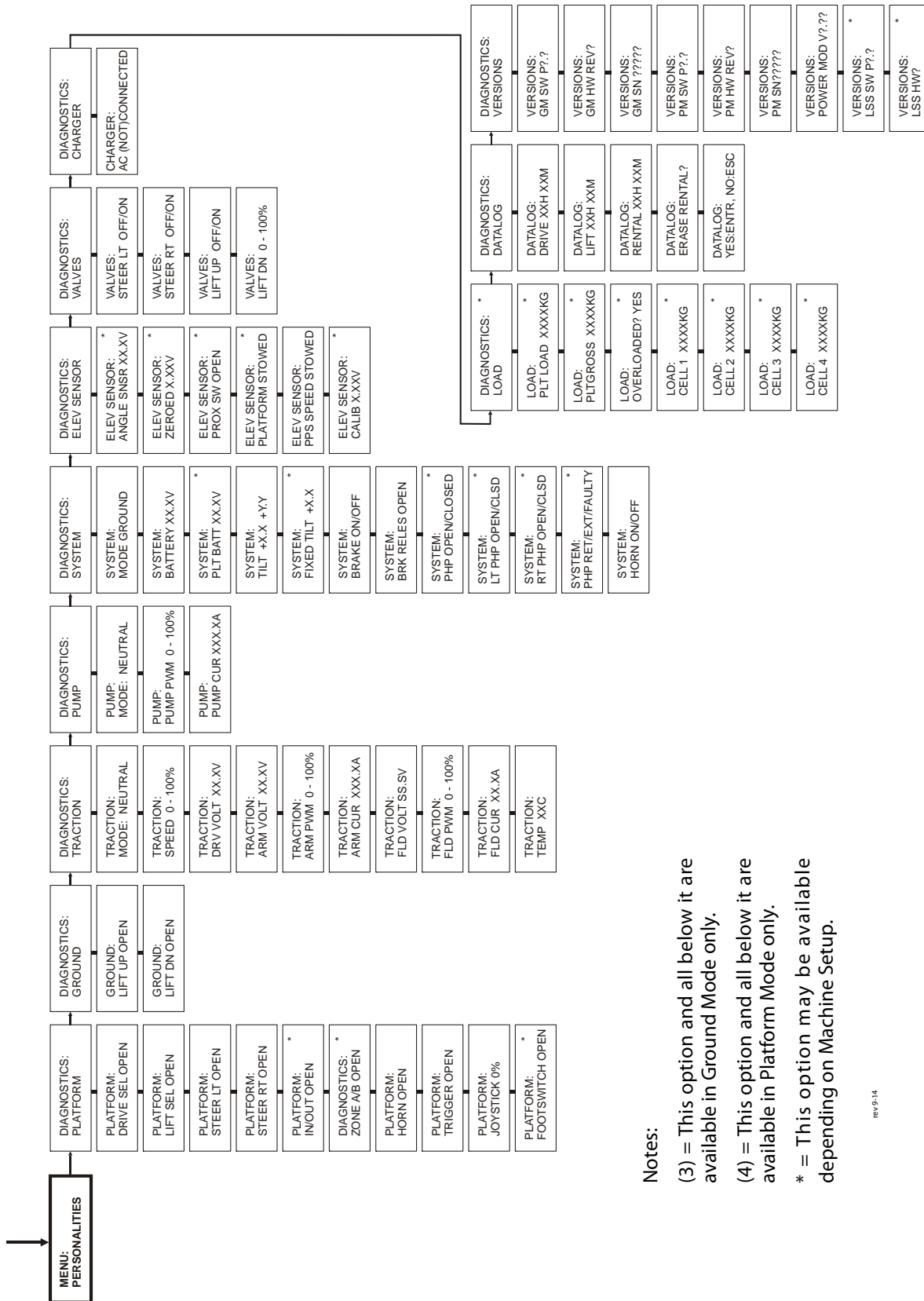


Figure 5-2. Analyzer Flow Chart (Sevcon) - Sheet 1 of 3



Continued on sheet 3

Figure 5-3. Analyzer Flow Chart (Sevcon) - Sheet 2 of 3



Notes:

(3) = This option and all below it are available in Ground Mode only.

(4) = This option and all below it are available in Platform Mode only.

\* = This option may be available depending on Machine Setup.

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Figure 5-4. Analyzer Flow Chart (Sevcon) - Sheet 3 of 3



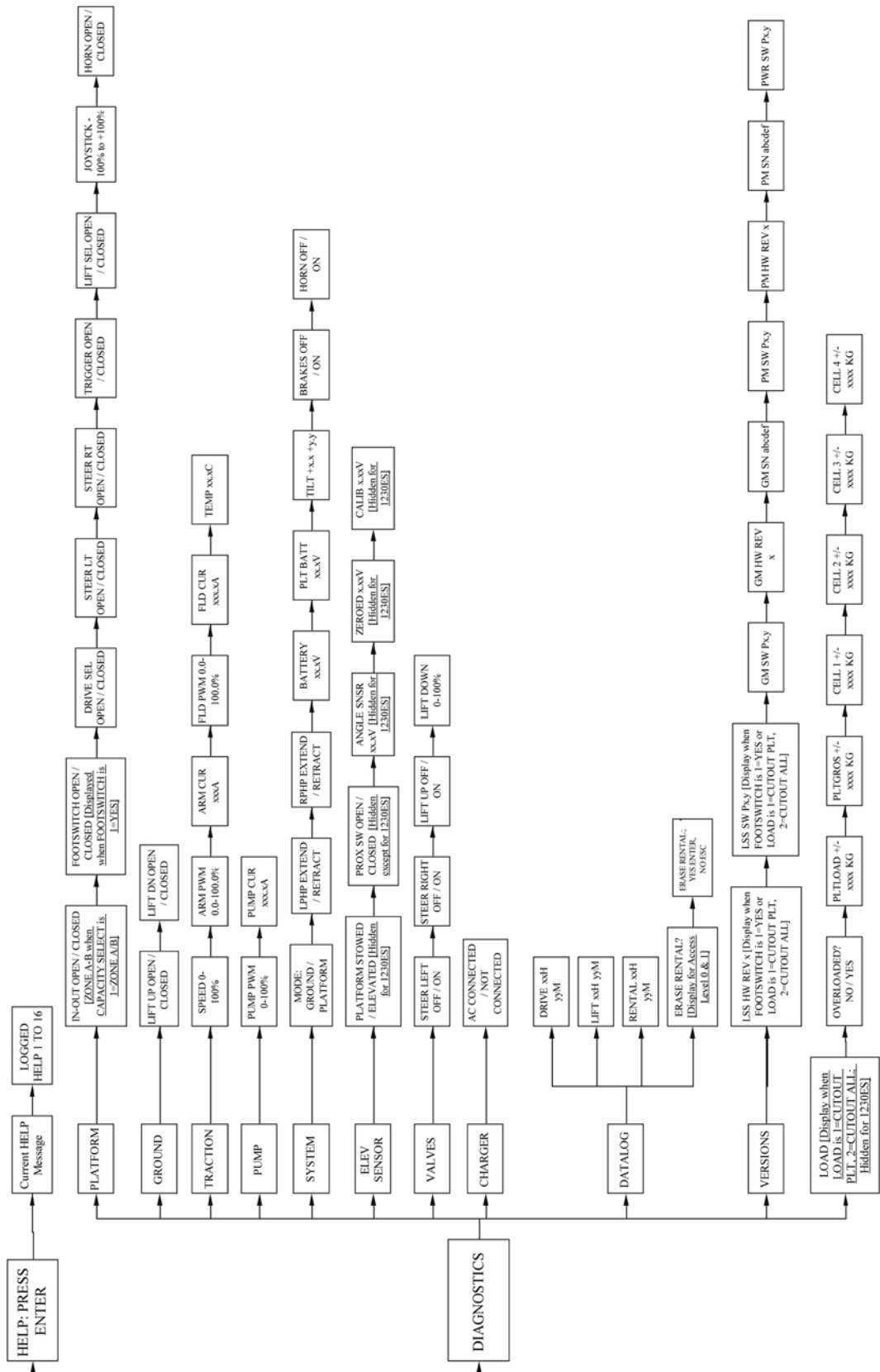


Figure 5-5. Analyzer Flow Chart (ZAPI) - Sheet 1 of 3

SECTION 5 - JLG CONTROL SYSTEM

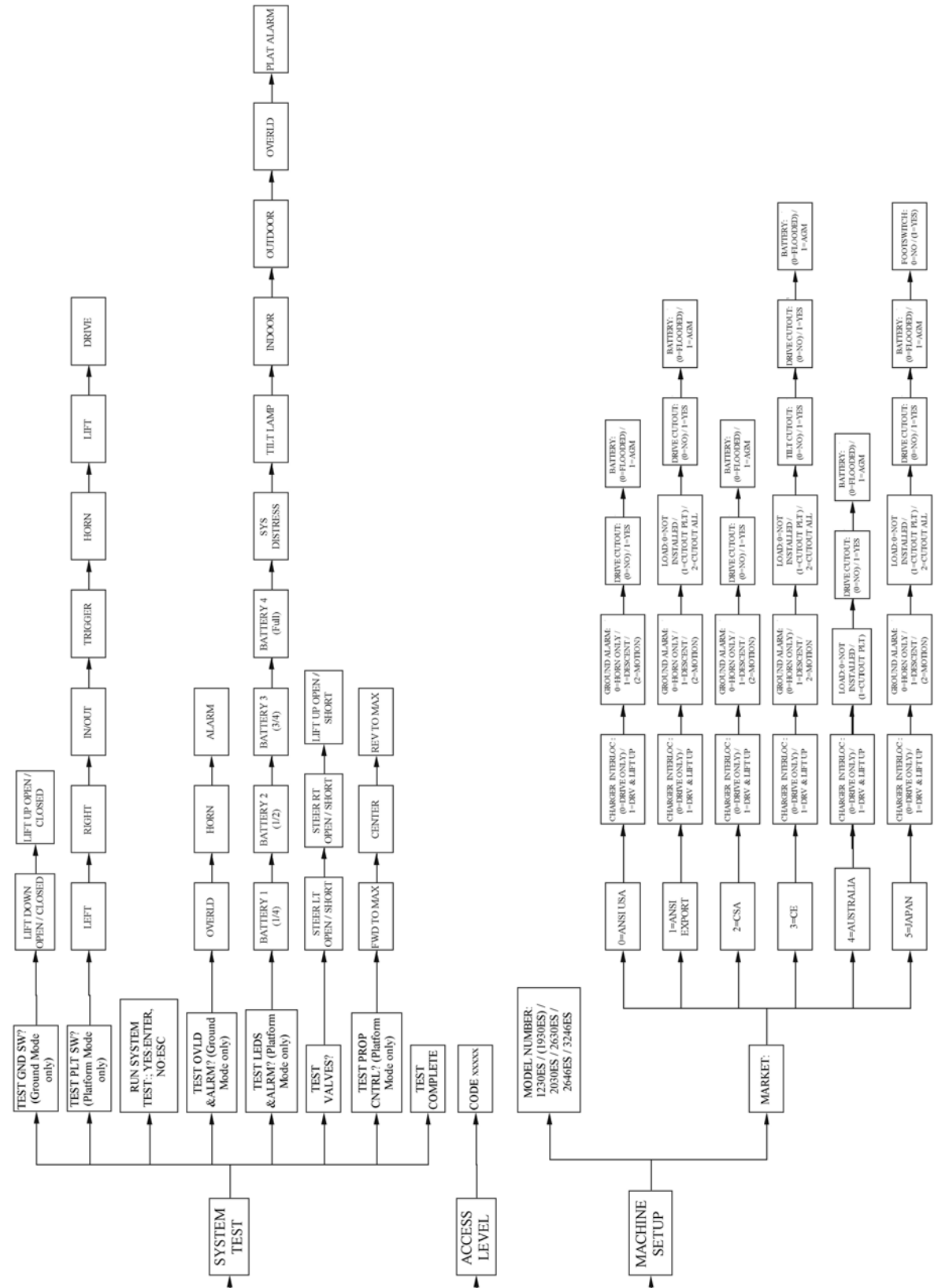


Figure 5-6. Analyzer Flow Chart (ZAPI) - Sheet 2 of 3

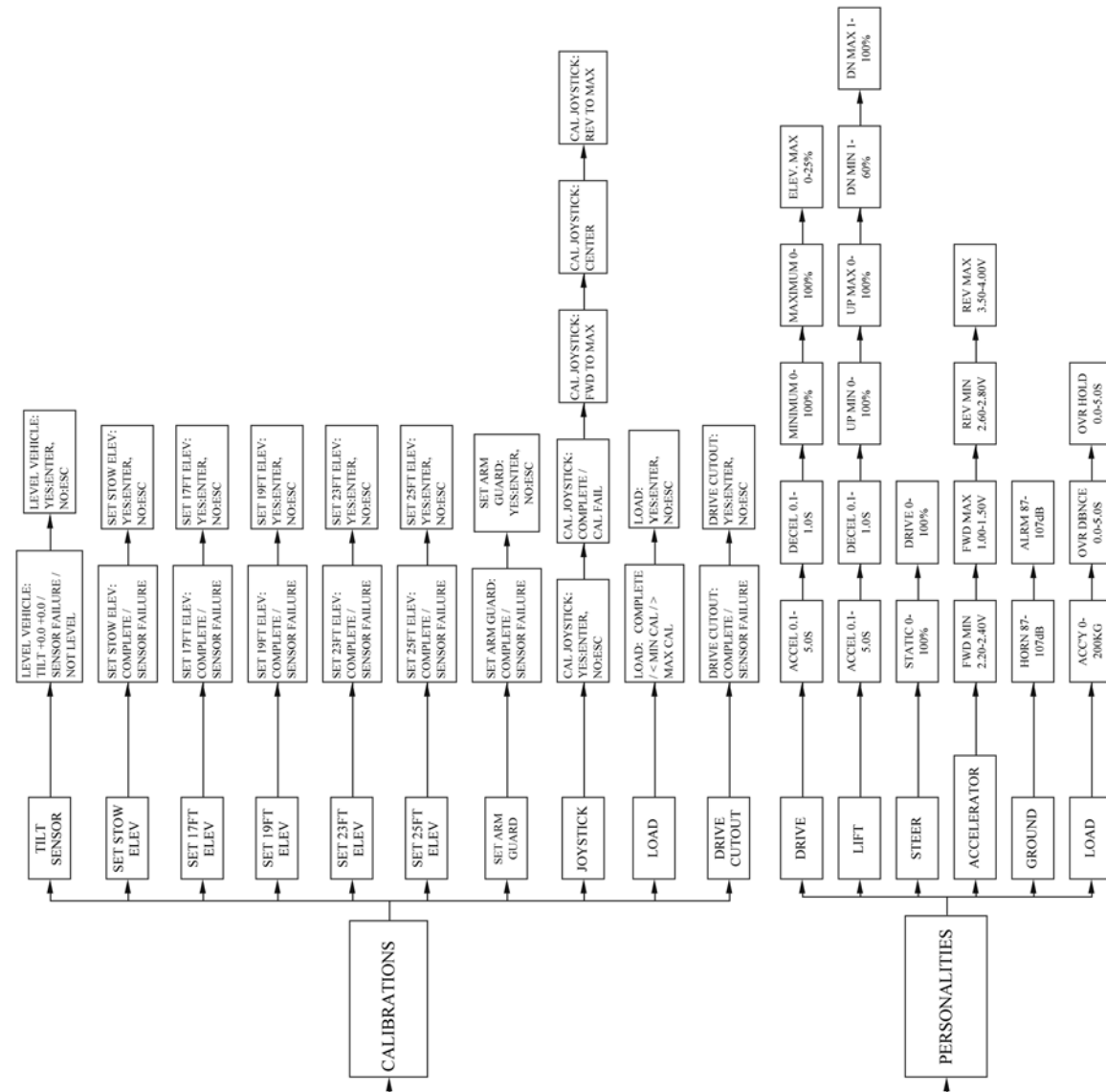


Figure 5-7. Analyzer Flow Chart (ZAPI) - Sheet 3 of 3

## SECTION 5 - JLG CONTROL SYSTEM

### 5.8 MACHINE MODEL ADJUSTMENT - SEVCON - 1600346 POWER MODULE

**Table 5-3. Machine Model Adjustment  
(Machines with Sevcon - 1600346 Power Module Only)**

Adjustment	Adjustment Range	1930ES	2030ES	2630ES	2646ES	3246ES
<b>DRIVE</b>						
ACCEL	0.1-5.0(Sec)	0.7	0.7	0.7	0.7	0.7
DECEL	0.1-1.0(Sec)	0.1	0.1	0.1	0.1	0.1
MINIMUM	0-25%	0	0	0	0	0
MAXIMUM	0-100%	100	100	100	100	100
ELEV. MAX.	0-25%	18	16	16	20	20
<b>LIFT</b>						
ACCEL	0.1-5.0(Sec)	0.5	0.5	0.5	0.5	0.5
DECEL	0.1-1.0(Sec)	0.1	0.1	0.1	0.1	0.1
UP MIN	0-50%	20	20	20	20	20
UP MAX	0-100%	100	100	100	100	100
DN MIN	1-60%	18	45	42	52	52
DN MAX	1-100%	60	85	63	80	80
<b>STEER</b>						
STATIC	0-100%	50	50	50	50	50
DRIVE	0-100%	30	30	30	30	30
<b>ACCELERATOR</b>						
FWD MIN	2.20-2.40V	2.25	2.25	2.25	2.25	2.25
FWD MAX	1.00-1.50V	1.20	1.20	1.20	1.20	1.20
REV MIN	2.60-2.80V	2.75	2.75	2.75	2.75	2.75
REV MAX	3.50-4.00V	3.80	3.80	3.80	3.80	3.80
<b>GROUND</b>						
HORN	87-107 dB	107	107	107	107	107
ALARM	87-107 dB	87	87	87	87	87
<b>LOAD</b>						
ACCY	0-200Kg	0	0	0	0	0
OVRDBNCE	0.0-5.0Sec	3.0	3.0	3.0	3.0	3.0
OVRHOLD	0.0-5.0Sec	5.0	5.0	5.0	5.0	5.0

4150472-1\*

\* Rev. I - Obsoleted by 1001115626

**NOTE:** These settings may change in order to achieve optimal performance on a machine by machine basis.

## 5.9 MACHINE MODEL ADJUSTMENT - ZAPI - 1001092456 POWER MODULE

**Table 5-4. Machine Model Adjustment  
(Machines with ZAPI - 1001092456 Power Module Only)**

Adjustment	Adjustment Range	1930ES	2030ES	2630ES	2646ES	3246ES
<b>DRIVE</b>						
ACCEL	0.1-5.0(Sec)	0.7	0.7	0.7	0.7	0.7
DECEL	0.1-1.0(Sec)	0.1	0.1	0.1	0.1	0.1
MINIMUM	0-25%	0	0	0	0	0
MAXIMUM	0-100%	100	100	100	100	100
ELEV. MAX.	0-25%	25	25	25	25	25
<b>LIFT</b>						
ACCEL	0.1-5.0(Sec)	0.5	0.5	0.5	0.5	0.5
DECEL	0.1-1.0(Sec)	0.1	0.1	0.1	0.1	0.1
UP MIN	0-50%	20	20	20	20	20
UP MAX	0-100%	100	100	100	100	100
DN MIN	1-60%	45	45	45	45	45
DN MAX	1-100%	75	75	75	75	75
<b>STEER</b>						
STATIC	0-100%	70	70	70	70	70
DRIVE	0-100%	30	30	30	30	30
<b>ACCELERATOR</b>						
FWD MIN	2.20-2.40V	2.23	2.23	2.23	2.23	2.23
FWD MAX	1.00-1.50V	1.19	1.19	1.19	1.19	1.19
REV MIN	2.60-2.80V	2.74	2.74	2.74	2.74	2.74
REV MAX	3.50-4.00V	3.78	3.78	3.78	3.78	3.78
<b>GROUND</b>						
HORN	10-100%	94	94	94	94	94
ALARM	10-100%	19	19	19	19	19
<b>LOAD</b>						
ACCY	0-200Kg	0	0	0	0	0
OVRDBNCE	0.0-5.0Sec	3.0	3.0	3.0	3.0	3.0
OVRHOLD	0.0-5.0Sec	5.0	5.0	5.0	5.0	5.0

100115627-D

**NOTE:** These settings may change in order to achieve optimal performance on a machine by machine basis.

## SECTION 5 - JLG CONTROL SYSTEM

### 5.10 MACHINE CONFIGURATION PROGRAMMING INFORMATION - SEVCON - 1600346

**NOTE:** When configuring an ES scissors machine, the machine configuration must be completed before any personality settings can be changed. Changing the personality settings first and then changing the model number of the machine configuration will cause the personality settings to return to default. Shaded entries are not available for the selected Market.

**Table 5-5. Machine Configuration Programming Information  
(Machines with Sevcon - 1600346 Power Module Only)**

Configuration Digit	Setting	Description	* Market Default Setting					
			0	1	2	3	4	5
1 (Model#)	1	1930ES	<i>(Set to your applicable ES Model 1 through 5)</i>					
	2	2030ES						
	3	2630ES						
	4	2646ES						
	5	3246ES						
2 (Market*)	0	ANSI USA	0 - (ANSI USA) <i>(Set to your applicable market)</i>					
	1	ANSI EXPORT						
	2	CSA						
	3	CE						
	4	AUSTRALIA						
3 (Tilt Cutout)	0	NO - Drive and lift up not prevented while tilted (Ground and Platform Mode).	1	1	1	0	1	1
	1	YES - Drive and lift up prevented while tilted (Ground and Platform Mode).						
4 (Drive Cutout)	0	No - Drive and lift up not prevented while elevated.	0					
	1	Yes - Drive and lift up prevented while elevated.						
5 (Charger Interlock)	0	DRIVE ONLY - Drive motion prevented while vehicle is charging.	0	0	0	0	0	0
	1	Drive and Lift Up - Drive and lift up motions are prevented while vehicle is charging. Required for CE.						
6 (Ground Alarm)	0	NOT INSTALLED - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, and as a horn.						
	1	DESCENT - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, as a horn and during Lift Down motion.	2	2	2	0	2	2
	2	MOTION - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, as a horn and during Drive and Lift motion.						
7 (LSS - Load Sensing System)	0	NOT INSTALLED - Load Sensing System (LSS) is not fitted to the vehicle.						
	1	CUTOFF PLT - Load Sensing System (LSS) is fitted and Platform Controls are prevented in the event of an Overload. Ground Controls remain functional. This is the default setting for CE machines.	0	1	0	1	0	1
	2	CUTOFF ALL - Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an overload.						
8 (Drive Motors)	0	PEERLESS - Vehicle is fitted with Peerless drive motors.	1					
	1	ADVANCED DC - Vehicle is fitted with ADVANCED DC drive motors.						
9 (Elev Prox)	0	NOT INSTALLED - Vehicle is not fitted with an Elevation Prox Sensor. Vehicle has Left and Right Brake Release Outputs, and Maintained Brake Release functionality.	0					
	1	INSTALLED - Vehicle is fitted with an Elevation Prox Sensor (original ES-Series). Vehicle has a single Brake Release Output, and Momentary Brake Release functionality.						
10 (Battery)	0	FLOODED - Batteries are conventional lead-acid type.	0					
	1	AGM - Batteries are absorbed glass mat type.						
11 (Footswitch)	0	NO - Vehicle is not fitted with a footswitch	0	0	0	0	0	1
	1	YES - Vehicle is fitted with a footswitch						

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**5.11 MACHINE CONFIGURATION PROGRAMMING INFORMATION - ZAPI - 1001092456**

**NOTE:** When configuring an ES scissors machine, the machine configuration must be completed before any personality settings can be changed. Changing the personality settings first and then changing the model number of the machine configuration will cause the personality settings to return to default. Shaded entries are not available for the selected Market.

**Table 5-6. Machine Configuration Programming Information (Machines with ZAPI - 1001092456 Power Module Only)**

Configuration Digit	Setting	Description	* Market Default Setting					
			0	1	2	3	4	5
1 (Model #)	1	1930ES	(Set to your applicable ES Model 1 through 5)					
	2	2030ES						
	3	2630ES						
	4	2646ES						
	5	3246ES						
2 (Market*)	0	ANSI USA	0 - (ANSI USA) (Set to your applicable market)					
	1	ANSI EXPORT						
	2	CSA						
	3	CE						
	4	AUSTRALIA						
3 (Tilt Cutout)	0	NO - Drive and lift up not prevented while tilted (Ground and Platform Mode).	1	1	1	0	1	1
	1	YES - Drive and lift up prevented while tilted (Ground and Platform Mode).						
4 (Drive Cutout)	0	NO - Drive and lift up not prevented while elevated.	0					
	1	YES - Drive and lift up prevented while elevated.						
5 (Charger Interlock)	0	DRIVE ONLY - Drive motion prevented while vehicle is charging.	0	0	0	0	0	0
	1	DRIVE AND LIFT UP - Drive and lift up motions are prevented while vehicle is charging. Required for CE.						
6 (Ground Alarm)	0	NOT INSTALLED - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, and as a horn.						
	1	DESCENT - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, as a horn and during Lift Down motion.	2	2	2	0	2	2
	2	MOTION - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled, as a horn and during Drive and Lift motion.						
7 (LSS - Load Sensing System)	0	NOT INSTALLED - Load Sensing System (LSS) is not fitted to the vehicle.						
	1	CUTOFF PLT - Load Sensing System (LSS) is fitted and Platform Controls are prevented in the event of an Overload. Ground Controls remain functional. This is the default setting for CE machines.	0	1	0	1	1	1
	2	CUTOFF ALL - Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an overload.						
8 (Battery)	0	FLOODED - Batteries are conventional lead-acid type.	0					
	1	AGM - Batteries are absorbed glass mat type.						
9 (Footswitch)	0	NO - Vehicle is not fitted with a footswitch	0	0	0	0	0	1
	1	YES - Vehicle is fitted with a footswitch						

100115626-C





## SECTION 6. DIAGNOSTIC TROUBLE CODES

### 6.1 INTRODUCTION

This section provides a reference for Diagnostic Trouble Codes (DTC) read from the Multifunction Digital Indicator (MDI). This section should only be used for machines equipped with a MDI and SEVCON Power Module-(ground board software version P1.13 or higher) or ZAPI Power Module-(ground board software version P1.0 or higher). For more information on the MDI or any sensors or indicators, refer to the appropriate section for the machine area. Many of the checks below require configuring and using a multimeter. Refer to Section 7: General Electrical Information & Schematics for multimeter basics. DTCs are sorted in groups by the first two digits, which is also the system distress lamp flash code. To troubleshoot multiple DTCs, start with the DTC with the higher first two digits. The machine is powered by four 6 Volt batteries in series, providing a nominal 24 Volts to the control system. Some procedures below refer to this nominal voltage (VMN) as 24V. Actual voltage measurements may differ based on the charge of the batteries. **If a correction is made during a check, conclude the check by cycling the machine power, using the emergency stop switch.** It may also be helpful to run a system test, ANALYZER -> SYSTEM TEST for intermittent or difficult problems.

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## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 6.3 DTC CHECK TABLES

#### 0-0 Help Comments

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
Error	Error (Displayed on MDI)	The MDI is powered, but cannot communicate with the control system.	<ul style="list-style-type: none"> <li>• Check the MDI connector.</li> <li>• Check the diagnostic connector.</li> <li>• Check continuity between MDI connector socket 6 and ground board connector socket J1-4.</li> <li>• Check continuity between MDI connector socket 4 and ground board connector socket J1-3.</li> <li>• Check that the ground board software version is P1.13 or higher.</li> </ul>
001	EVERYTHING OK	The normal help message in platform mode. Displays on the analyzer only.	
002	GROUND MODE OK	The normal help message in ground mode. Displays on the analyzer only.	
003	ALARM SOUNDING - TILTED & ABOVE ELEVATION	Control system senses that the platform is elevated and the vehicle is tilted, and the machine not configured to cutout.	<ul style="list-style-type: none"> <li>• Check that the machine is tilted. If so, lower the platform and reposition the machine to a level surface.</li> <li>• Fully stow the platform.</li> <li>• The tilt sensor is part of the ground control box. Check that the ground control box is secured to the machine.</li> <li>• Check that the pothole protection switches are securely mounted.</li> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check the ANALYZER -&gt; MACHINE SETUP -&gt; MARKET configuration.</li> <li>• If MARKET is set to CE, ensure ANALYZER -&gt; MACHINE SETUP -&gt; TILT CUTOFF parameter is set as desired.</li> <li>• Backprobing ground board J1-18 should show about 0 volts.</li> <li>• Backprobing ground board J1-10 should show about 0 volts.</li> <li>• Check pothole protection switch adjustment.</li> <li>• Calibrate the elevation sensor, see Section 5.5.</li> <li>• Calibrate the tilt sensor, see Section 5.2.</li> </ul>
004	DRIVING AT CUTBACK - ABOVE ELEVATION	The platform is elevated and the machine is driving.	<ul style="list-style-type: none"> <li>• Fully stow the platform.</li> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check that the pothole protection switches are securely mounted.</li> <li>• Check the lift/drive switch.</li> <li>• Backprobing ground board J1-18 should show about 0 volts.</li> <li>• Backprobing ground board J1-10 should show about 0 volts.</li> <li>• Check function of elevation angle sensor. ANALYZER -&gt; DIAGNOSTICS -&gt; ELEV SENSOR -&gt; ZEROED should be about 0V when stowed and about 0.15V at cutback.</li> </ul>

 **0-0 Help Comments**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
005	DRIVE & LIFT UP PREVENTED - TILTED & ELEVATED	Driving is not possible since the platform is elevated and the chassis is not level.	<ul style="list-style-type: none"> <li>• Check that the machine is tilted. If so, lower the platform and reposition the machine to a level surface.</li> <li>• Fully stow the platform.</li> <li>• The tilt sensor is part of the ground control box. Check that the ground control box is secured to the machine.</li> <li>• Check that the pothole protection switches are securely mounted.</li> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check the ANALYZER -&gt; MACHINE SETUP -&gt; MARKET configuration.</li> <li>• If MARKET is set to CE, ensure ANALYZER -&gt; MACHINE SETUP -&gt; TILT CUTOFF parameter is set as desired.</li> <li>• Check pothole protection switch adjustment.</li> <li>• Backprobing ground board J1-18 should show about 0 volts.</li> <li>• Backprobing ground board J1-10 should show about 0 volts.</li> <li>• Calibrate the elevation sensor, see Section 5.5.</li> <li>• Calibrate the tilt sensor, see Section 5.2.</li> </ul>
006	LIFT UP PREVENTED - MAX HEIGHT ZONE A	The vehicle has reached the maximum height and further lift up motion is not possible. Applicable to 2630ES or 3246ES.	<ul style="list-style-type: none"> <li>• Check that the zone is set appropriately for the platform load.</li> <li>• Check that the platform height is at the rated maximum height specification (20' for 2630 or 26' for the 3246).</li> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• If there are any elevation sensor faults (DTC 251, 252, 2511, or 2512), troubleshoot those first.</li> <li>• Check that ANALYZER -&gt; MACHINE SETUP -&gt; MODEL setting is correct.</li> <li>• Check that ANALYZER -&gt; MACHINE SETUP -&gt; MARKET setting is correct.</li> <li>• Check ANALYZER -&gt; DIAGNOSTICS -&gt; ELEV SENSOR -&gt; ZEROED is about 1.53V for the 3246 or about 1.22V for the 2630 when at full height. If not, repair or replace the elevation angle sensor.</li> </ul>
007	DRIVING AT CUTBACK - POT-HOLE STILL ENGAGED	While stowed, drive speed is reduced since the control system detected that the pot-hole protection mechanism failed to retract.	<ul style="list-style-type: none"> <li>• Check for obstructions around the pot-hole protection mechanisms.</li> <li>• Check that the PHP switches are securely mounted.</li> <li>• Check PHP switches wiring from the ground board and for proper operation. The left PHP input (24V) is from J1-9 and its output (24V when deployed) is to J1-10. The right PHP input (24V) is from J1-17 and its output (24V when deployed) is to J1-18.</li> </ul>
008	FUNCTIONS LOCKED OUT - SYSTEM POWERED DOWN	After 2 hours without activity, the control system enters a low-power state to preserve battery charge.	<ul style="list-style-type: none"> <li>• Normal operation should resume after a power cycle.</li> <li>• Check batteries charge, condition, etc.</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 0-0 Help Comments

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
009	DRIVE PREVENTED - ELEVATED ABOVE DRIVE CUTOUT HEIGHT	The platform is elevated above the calibrated cutout height.	<ul style="list-style-type: none"> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check the ANALYZER -&gt; MACHINE SETUP -&gt; MARKET configuration.</li> <li>• If MARKET is set to Japan, ensure ANALYZER -&gt; MACHINE SETUP -&gt; DRIVE CUTOUT parameter is set as desired.</li> </ul>

### 2-1 Power-Up

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
211	POWER CYCLE	This help message is issued at each power cycle. Displays on the analyzer only.	Normal operation. No check necessary.
212	KEYSWITCH FAULTY	Both platform and ground modes are selected simultaneously. Defaults to ground mode.	<ul style="list-style-type: none"> <li>• Check key switch function.</li> <li>• Backprobe J2-3 with the keyswitch in the ground position. Voltage should be under 6V. Otherwise, keyswitch or wiring faulty.</li> <li>• Backprobe J2-4 with the keyswitch in the platform position. Voltage should be under 6V. Otherwise, keyswitch or wiring faulty.</li> <li>• Check key switch wiring to ground board J2-3 and J2-4 and to emergency stop switch.</li> <li>• Replace ground board.</li> </ul>

### 2-2 Platform Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
221	FUNCTION PROBLEM - HORN PERMANENTLY SELECTED	The horn switch was closed during power-up in platform mode.	<ul style="list-style-type: none"> <li>• Check if the horn switch is damaged, obstructed or jammed.</li> <li>• Disconnect the horn switch ribbon cable on the platform board. If DTC still present, replace the platform board. If DTC 221 is no longer present, replace the horn switch or platform board.</li> </ul>
222	FUNCTION PROBLEM - INDOOR / OUTDOOR PERMANENTLY SELECTED	The indoor / outdoor (zone A / zone B) switch was closed during power-up in platform mode.	<ul style="list-style-type: none"> <li>• Check if the indoor/outdoor (zone A / zone B) capacity switch is damaged, obstructed or jammed.</li> <li>• Replace platform board.</li> </ul>
223	FUNCTION PROBLEM - DRIVE & LIFT ACTIVE TOGETHER	The drive and lift inputs are closed simultaneously in platform mode.	<ul style="list-style-type: none"> <li>• Check drive/lift switch for visible damage.</li> <li>• Check switch continuity. There should only be continuity from the center post to one of the outer posts at a time. Otherwise, replace the switch.</li> <li>• Check drive/lift switch signal and wiring to the platform board. Its input (0V) is from platform board terminal J1-11. "Lift" selection output (0V when selected) is to platform board terminal J1-9. "Drive" selection output (0V when closed) is to platform board terminal J1-10.</li> <li>• Replace platform board.</li> </ul>

** 2-2 Platform Controls**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
224	FUNCTION PROBLEM - STEER LEFT PERMANENTLY SELECTED	The steer left switch was closed during power-up in platform mode.	<ul style="list-style-type: none"> <li>• Check if the steer left switch is obstructed or jammed.</li> <li>• Check steer left switch and its wiring. The steer left switch input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-15.</li> <li>• Replace platform board.</li> </ul>
225	FUNCTION PROBLEM - STEER RIGHT PERMANENTLY SELECTED	The steer right switch was closed during power-up in platform mode.	<ul style="list-style-type: none"> <li>• Check if the steer right switch is obstructed or jammed.</li> <li>• Check steer right switch and its wiring to the platform board. The steer right switch input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-16.</li> <li>• Replace platform board.</li> </ul>
226	ACCELERATOR FAULTY - WIPER OUT OF RANGE	The joystick signal is outside the acceptable range of 0.50V - 4.5V, or is unstable.	<ul style="list-style-type: none"> <li>• Center joystick and check to see if a power cycle will clear DTC.</li> <li>• Check the joystick signal and its wiring. The joystick input (5V) is from the platform board terminal J1-5, its output (2.5V with joystick at center) to the platform board terminal J1-6, and its ground (0V) is to the platform board terminal J1-7. Observe output signal while slowly operating joystick.</li> <li>• Replace platform board.</li> </ul>
227	STEER SWITCHES FAULTY	The steer left and steer right inputs were closed simultaneously.	<ul style="list-style-type: none"> <li>• Check if the steer switches are damaged, obstructed or jammed.</li> <li>• Check the steer switch signals and wiring to the platform board. The steer switch input (24V) is from platform board terminal J1-1, outputs (24V when closed) are to platform board terminals J1-15 and J1-16 (left and right).</li> <li>• Replace platform board.</li> </ul>
228	FUNCTION LOCKED OUT - ACCELERATOR NOT CENTERED	The joystick was not centered at power-up.	<ul style="list-style-type: none"> <li>• Release joystick and allow to center.</li> <li>• Check if the joystick is obstructed or jammed.</li> <li>• Check the joystick signal and its wiring. The joystick input (5V) is from the platform board terminal J1-5, its output (2.5V with joystick at center) to the platform board terminal J1-6, and its ground (0V) is to the platform board terminal J1-7. Observe output signal while slowly operating joystick.</li> <li>• Replace platform board.</li> </ul>
229	FUNCTION PROBLEM - TRIGGER PERMANENTLY CLOSED	The trigger switch was closed during power-up in platform mode.	<ul style="list-style-type: none"> <li>• Check if the trigger switch is obstructed or jammed.</li> <li>• Check the trigger switch signal and wiring to the platform board. The trigger input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-8.</li> <li>• Replace platform board.</li> </ul>
2210	TRIGGER CLOSED TOO LONG WHILE IN NEUTRAL	The trigger switch was closed for more than five seconds while the joystick was centered.	<ul style="list-style-type: none"> <li>• Check if the trigger switch is obstructed or jammed.</li> <li>• Check the trigger switch signal and wiring to the platform board. The trigger input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-8.</li> <li>• Replace platform board.</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 2-2 Platform Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
2232	FUNCTION PROBLEM - DRIVE & LIFT BOTH OPEN	The drive and lift inputs are both de-energized in Platform Mode.	<ul style="list-style-type: none"> <li>• Check if either function is active, if Yes;</li> <li>• Repair the wiring or switch to clear the message.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>

### 2-3 Ground Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
231	FUNCTION PROBLEM - LIFT PERMANENTLY SELECTED	The ground control box lift switch was closed up or down, during power-up in ground mode.	<ul style="list-style-type: none"> <li>• Check if the lift switch is obstructed or jammed.</li> <li>• Check the lift switch signal and wiring to the ground board. The lift switch input (24V) is from ground board terminal J2-4, and its outputs (24V when closed) are to ground board terminals J2-6, J2-7 (up and down).</li> <li>• Replace ground board.</li> </ul>
232	GROUND LIFT UP / DOWN ACTIVE TOGETHER	The lift up / down inputs are closed simultaneously.	<ul style="list-style-type: none"> <li>• Check if the lift switch is obstructed or jammed.</li> <li>• Check the lift switch signal and wiring to the ground board. The lift switch input (24V) is from ground board terminal J2-4, and its outputs (24V when closed) are to ground board terminals J2-6 (up), J2-7 (down).</li> <li>• Replace ground board.</li> </ul>
233	FUNCTION PROBLEM - BRAKE RELEASE PERMANENTLY SELECTED	The manual brake release switch was closed during power-up.	<ul style="list-style-type: none"> <li>• Check if the brake release switch is obstructed or jammed.</li> <li>• Check the brake release switch signal and wiring to the ground board. The brake release switch input (24V) is from ground board terminal J1-19, and its output (24V when closed) is to ground board terminal J1-20.</li> <li>• If the brakes are released, the machine can be pushed or moved without drive motor power.</li> <li>• Replace ground board.</li> </ul>

### 2-5 Function Prevented

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
251	ELEV ANGLE SENSOR FAULTY - VOLTAGE OUT OF RANGE	The elevation angle sensor input voltage is outside the acceptable range of 0.10V - 4.50V.	<ul style="list-style-type: none"> <li>• Check that the platform elevation sensor is securely mounted and undamaged.</li> <li>• Check voltage as displayed on ANALYZER -&gt; DIAGNOSTICS -&gt; ELEV SENSOR -&gt; ANGLE SNSR. Backprobe ground board J1-15. If this voltage disagrees with the ANGLE SNSR voltage, replace the ground board.</li> <li>• Backprobe the elevation angle sensor connector. Terminal A should be 4.7V, terminal C should be 0V.</li> <li>• Check the elevation angle sensor signal and wiring to the ground board. The elevation angle sensor input is from ground board terminal J1-14 (4.7V), its output (0.1 - 1.2V when stowed) is to ground board terminal J1-15, and its ground is to ground board terminal J1-16.</li> <li>• Replace the ground board.</li> </ul>



**🔧 2-5 Function Prevented**

<b>DTC</b>	<b>FAULT MESSAGE</b>	<b>DESCRIPTION</b>	<b>CHECK</b>
252	ELEV ANGLE SENSOR HAS NOT BEEN CALIBRATED	The elevation angle sensor has not been calibrated.	<ul style="list-style-type: none"> <li>• Calibrate the elevation angle sensor to clear fault. See Section 5.5.</li> </ul>
253	DRIVE PREVENTED - CHARGER CONNECTED	Driving is not possible while the vehicle is charging.	<ul style="list-style-type: none"> <li>• Check if the charger is connected to off board power source and disconnect if desired.</li> <li>• Check ANALYZER -&gt; MACHINE SETUP -&gt; CHARGER INTERLOC is set as desired.</li> <li>• Check that charger's red (positive) battery wire connector terminal is receiving power (24V) from batteries.</li> <li>• Check signal from charger interlock connector terminal 2 to ground board terminal J1-29, where 0VDC indicates charging in process.</li> </ul>
254	DRIVE & LIFT UP PREVENTED - CHARGER CONNECTED	Drive or lift is not possible while the vehicle is charging AND is configured to prevent all motion.	<ul style="list-style-type: none"> <li>• Check if the charger is connected to off board power source and disconnect if desired.</li> <li>• Check ANALYZER -&gt; MACHINE SETUP -&gt; CHARGER INTERLOC is set as desired. (Must be in ACCESS LEVEL 1 to change.)</li> <li>• Check that charger's red (positive) battery wire connector terminal is receiving power (24V) from batteries.</li> <li>• Check signal from charger interlock connector terminal 2 to ground board terminal J1-29, where 0VDC indicates charging in process.</li> </ul>
255	PLATFORM OVERLOADED	The load sensing system measured platform load is excessive.	<ul style="list-style-type: none"> <li>• Remove excess weight from the platform.</li> <li>• Check that the platform is not caught on something, preventing up or down movement.</li> <li>• If any CAN bus faults are active, troubleshoot those first.</li> <li>• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
256	DRIVE PREVENTED - POT-HOLE NOT ENGAGED	Driving is not possible while elevated since the pot-hole protection system failed to deploy.	<ul style="list-style-type: none"> <li>• Check for obstructions or mechanical problems around the pot-hole protection mechanisms.</li> <li>• Check that the PHP switches are securely mounted.</li> <li>• Adjust pot-hole protection switches.</li> <li>• Check the pothole protection switches signal and wiring to the ground board. The left pot-hole protection switch input (24V) is from ground board terminal J1-9, and its output (24V when deployed) is to ground board terminal J1-10. The right pot-hole protection switch input (24V) is from ground board terminal J1-17, and its output (24V when deployed) is to ground board terminal J1-18.</li> </ul>
257	ELEV PROX PERMANENTLY CLOSED - CHECK PROX AND ANGLE ADJUSTMENT	The elevation proximity switch shows the platform to be stowed, while the elevation angle sensor shows the platform to be raised. The elevation proximity switch is only found on certain older lifts. This switch is not used on current machines so this DTC should not occur.	<ul style="list-style-type: none"> <li>• Verify that an elevation proximity switch is present on the machine. If not, ensure ANALYZER -&gt; MACHINE SETUP -&gt; ELEV PROX is set to NOT INSTALLED. If the switch is present, set ELEV PROX to INSTALLED and check switch continuity. The switch should close when placed in close proximity to ferrous metal.</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 2-5 Function Prevented

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
258	DRIVE & LIFT PRE-VENTED - BRAKES ELECTRICALLY RELEASED FOR TOWING	Manual brake release mode is activated with the switch in the battery box near the ground control box. Drive or lift is not possible.	<ul style="list-style-type: none"> <li>• Push manual brake release switch again or cycle power to clear manual brake release mode.</li> <li>• Check if the brake release switch is obstructed or jammed.</li> <li>• Check the brake release switch signal and wiring to the ground board. The switch input (24V) is from ground board terminal J1-19, and its output (24V when closed) is to ground board terminal J1-20.</li> <li>• Replace ground board.</li> </ul>
259	MODEL CHANGED - HYDRAULICS SUSPENDED - CYCLE EMS	The model selection has been changed.	<ul style="list-style-type: none"> <li>• Check ANALYZER -&gt; MACHINE SETUP -&gt; MODEL NUMBER.</li> <li>• Replace ground board.</li> </ul>
2510	DRIVE PREVENTED - BRAKES NOT RELEASING	While driving on a level surface, armature current was > 150A for five seconds. Brakes assumed to not be releasing properly.	<ul style="list-style-type: none"> <li>• Ensure vehicle is not stuck on something preventing movement.</li> <li>• Check / repair drive motor wiring, brakes or mechanical issues.</li> </ul>
2511	ELEV ANGLE SENSOR FAULTY - NOT MOUNTED	The input voltage from the elevation angle sensor indicates the elevation angle sensor is not mounted.	<ul style="list-style-type: none"> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check that the elevation angle sensor mechanisms are intact.</li> <li>• Replace elevation angle sensor.</li> </ul>
2512	ELEV ANGLE SENSOR NOT DETECTING CHANGE	The input voltage from the elevation angle sensor did not change while vehicle was lifting up.	<ul style="list-style-type: none"> <li>• Check that the elevation angle sensor is securely mounted.</li> <li>• Check elevation angle sensor is not jammed or obstructed.</li> <li>• If there are any other elevation angle sensor, joystick, or lift up faults, troubleshoot them before continuing.</li> <li>• Replace elevation angle sensor.</li> </ul>

### 3-1 Line Contactor Open Circuit

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
311	OPEN CIRCUIT LINE CONTACTOR	The power modules line contactor did not close when energized. Drive, steer and lift up prevented.	<ul style="list-style-type: none"> <li>• Check contactor main contact wiring to battery (+) terminal and power controller terminal B+.</li> <li>• Contactor solenoid resistance should measure about 52 Ohms.</li> <li>• Check contactor solenoid wiring to power module 12 position connector terminal 8 and ground board terminal J1-19.</li> <li>• Check that power module 12 position connector terminal 8 goes from 24V to near 0V while contactor should be closing. If this happens replace contactor.</li> <li>• Replace the line contactor.</li> </ul>
312	CONTACTOR DRIVER PERMANENTLY OFF	The power modules line contactor drive circuitry failed to energize when requested. Drive, steer and lift up prevented.	<ul style="list-style-type: none"> <li>• Check continuity between contactor connector pin 1 and ground board socket J1-19.</li> <li>• Contactor solenoid resistance should measure about 52 Ohms.</li> <li>• Check continuity between contactor connector pin 2 and power module connector socket 8.</li> <li>• Replace power module.</li> </ul>

**🔧 3-1 Line Contactor Open Circuit**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
314	AUXILIARY RELAY - OPEN CIRCUIT	The auxiliary relay did not close when energized.	<ul style="list-style-type: none"> <li>• Check the auxiliary relay coil and associated wiring to J1-13 and J1-32.</li> <li>• No voltage on J1-28.</li> <li>• HEALTH (Status LED) - ON</li> </ul>

**🔧 3-2 Line Contactor Short Circuit**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
321	LINE CONTACTOR MISWIRED ON OR WELDED	Battery voltage was present at the power module B+ terminal at power up. Drive, steer and lift up prevented.	<ul style="list-style-type: none"> <li>• Check wiring of contactor.</li> <li>• Check resistance between the studs of the contactor while disconnected from the machine.</li> <li>• Check contactor main contact wiring to battery (+) terminal and power module terminal B+.</li> <li>• Check continuity between contactor connector pin 1 and ground board socket J1-19.</li> <li>• Check continuity between contactor connector pin 2 and power module 12 position connector terminal 8.</li> <li>• Measure voltage between power model B+ and B- terminals. If 24V is present, replace line contactor.</li> <li>• Replace power module.</li> </ul>
322	CONTACTOR DRIVER PERMANENTLY ON	The power modules line contactor drive circuitry failed to de-energize when requested. Drive, steer and lift up prevented.	<ul style="list-style-type: none"> <li>• Check continuity between contactor connector pin 1 and ground board socket J1-19.</li> <li>• Check continuity between contactor connector pin 2 and power module 12 position connector terminal 8.</li> <li>• Replace power module.</li> </ul>

**🔧 3-3 Ground Output Driver**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
331	BRAKE SHORT TO BATTERY	The ground board detected voltage while the brake solenoid was commanded off.	<ul style="list-style-type: none"> <li>• Ensure ANALYZER -&gt; MACHINE SETUP -&gt; ELEV PROX is set to NOT INSTALLED.</li> </ul>
332	BRAKE OPEN CIRCUIT	The ground board did not detect current flow to the brake solenoid during normal operation.	<ul style="list-style-type: none"> <li>• Ensure ANALYZER -&gt; MACHINE SETUP -&gt; ELEV PROX is set to NOT INSTALLED.</li> </ul>
333	LIFT UP SHORT TO BATTERY	The ground board detected voltage while the lift up solenoid was commanded off at power up.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The lift up solenoid resistance should measure about 30 Ohms. The lift up solenoid is powered with 24V from ground board J1-25, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
334	LIFT UP OPEN CIRCUIT	The ground board did not detect current flow to the lift up solenoid during power up.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The lift up solenoid resistance should measure about 30 Ohms. The lift up solenoid is powered with 24V from ground board J1-25, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
335	LIFT DN SHORT TO BATTERY	The ground board detected voltage while the lift down solenoid was commanded off.	<ul style="list-style-type: none"> <li>• Check ANALYZER -&gt; MACHINE SETUP -&gt; ELEV PROX is set to NOT INSTALLED</li> <li>• Check for continuity through this circuit. The lift down solenoid resistance should measure about 20 Ohms. The lift down solenoid is powered (PWM) by ground board J1-26, and its ground is to ground board J1-27.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
336	LIFT DN OPEN CIRCUIT	The ground board did not detect current flow to the lift down solenoid during normal operation.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The lift down solenoid resistance should measure about 20 Ohms. The lift down solenoid is powered (PWM) by ground board J1-26, and its ground is to ground board J1-27.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
337	STEER LEFT SHORT TO BATTERY	The ground board detected voltage while the steer left solenoid was commanded off at power up.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Steer left solenoid resistance should measure about 30 Ohms. The steer left solenoid is powered with 24V from ground board J1-21, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
338	STEER LEFT OPEN CIRCUIT	The ground board did not detect current flow to the steer left solenoid during normal operation.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Steer left solenoid resistance should measure about 30 Ohms. The steer left solenoid is powered with 24V from ground board J1-21, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
339	STEER RIGHT SHORT TO BATTERY	The ground board detected voltage while the steer right solenoid was commanded off.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Steer right solenoid resistance should measure about 30 Ohms. The steer right solenoid is powered with 24V from ground board J1-22, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
3310	STEER RIGHT OPEN CIRCUIT	The ground board did not detect current flow to the steer right solenoid during normal operation.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Steer right solenoid resistance should measure about 30 Ohms. The steer right solenoid is powered with 24V from ground board J1-22, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
3311	GROUND ALARM SHORT TO BATTERY	The ground board detected voltage while the ground alarm was commanded off.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The ground alarm solenoid is powered with 24V from ground board J1-19, its PWM signal is from ground board J1-28, and its ground is to ground board J1-30, 37. There should be about 1500 Ohms between ground alarm connector pin 1 and pin 3.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>

** 3-3 Ground Output Driver**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
3312	LEFT BRAKE SHORT TO BATTERY	The ground board detected voltage while the left brake was commanded off.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The left brake is powered with 24V from ground board J1-23, and its ground is to ground board J1-30, 37. Brake solenoid resistance should measure about 20 Ohms.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
3313	RIGHT BRAKE SHORT TO BATTERY	Voltage was detected on the right brake solenoid when the ground board output was commanded off during power-up.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Brake solenoid resistance should measure about 20 Ohms. The right brake is powered with 24V from ground board J1-24, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
3314	LEFT BRAKE OPEN CIRCUIT	Current flow to the left brake solenoid was not detected during normal left brake operation.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. The left brake is powered with 24V from ground board J1-23, and its ground is to ground board J1-30, 37. Brake solenoid resistance should measure about 20 Ohms.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
3315	RIGHT BRAKE OPEN CIRCUIT	The ground board did not detect current flow to the right brake during normal operation.	<ul style="list-style-type: none"> <li>• Check for continuity through this circuit. Brake solenoid resistance should measure about 20 Ohms. The right brake is powered with 24V from ground board J1-24, and its ground is to ground board J1-30, 37.</li> <li>• Inspect the wiring for physical damage.</li> <li>• Replace ground board.</li> </ul>
33297	LEFT BRAKE - SHORT TO GROUND	Drive and Steer Prevented	<ul style="list-style-type: none"> <li>• Excessive current flow to the Left Brake Solenoid was detected (J1-34 NLB).</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
33298	STEER LEFT VALVE - SHORT TO GROUND	Drive, Steer and Lift Up Prevented	<ul style="list-style-type: none"> <li>• Excessive current flow to the steer left solenoid detected (J2-9 NLV).</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
33299	LINE CONTACTOR COIL - SHORT TO BATTERY	Drive, Lift and Steer Prevented	<ul style="list-style-type: none"> <li>• Voltage from an external source was detected on the Negative Main Line Contactor.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
33302	NEGATIVE SUPPLY - SHORT TO BATTERY	Drive, Lift, and Steer Prevented	<ul style="list-style-type: none"> <li>• At power-up, the system module detected an external short on J1-12, J1-17, J1-23, J2-14 or J2-15. Normally these pins are grounded by the System Module. All functions are prevented to protect the control system.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
33303	NEGATIVE SUPPLY - SHORT TO GROUND	Drive, Lift and Steer Prevented	<ul style="list-style-type: none"> <li>• At power-up, the System Module detected an external short on J1-12, J1-17, J2-14 or J2-15. Normally these pins are grounded by the System Module. Since the external ground may compromise integrity, all functions will be prevented.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
33304	RIGHT BRAKE - SHORT TO GROUND	Drive, and Steer Prevented	<ul style="list-style-type: none"> <li>• Excessive current flow to the Right Brake solenoid was detected (J1-33 NRB).</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
33305	STEER RIGHT VALVE - SHORT TO GROUND	Drive, Steer, and Lift Up Prevented	<ul style="list-style-type: none"> <li>Excessive current flow to the Steer Right Solenoid was detected (J2-18 NRV).</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
33406	LIFT UP VALVE - SHORT TO GROUND	Drive, Steer, and Lift Up Prevented	<ul style="list-style-type: none"> <li>Excessive current flow to the Lift Up Solenoid was detected at (J2-2 PDV or J2-16 NDV).</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
33407	LIFT DN VALVE - SHORT TO GROUND	Lift Up and Down Prevented	<ul style="list-style-type: none"> <li>Excessive current flow to the Lift Down Solenoid was detected (J2-16 NDV).</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>

### 4-2 Thermal Limit (SOA)

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
421	POWER MODULE TOO HOT - PLEASE WAIT	The power module has reached thermal cutout.	<ul style="list-style-type: none"> <li>Power down and allow to cool.</li> <li>Do not operate in ambients over 140° F (60° C).</li> <li>Check for jammed or obstructed drive motors.</li> <li>Check for excessively high current consumption in the pump, ANALYZER -&gt; DIAGNOSTICS -&gt; PUMP -&gt; PUMP CUR over 130 Amps with an empty deck.</li> <li>Check for excessively high traction current consumption, ANALYZER -&gt; DIAGNOSTICS -&gt; TRACTION -&gt; ARM CUR over 120 Amps while driving on the level.</li> </ul>
422	DRIVING AT CUTBACK - POWER MODULE CURRENT LIMIT	The drive portion of the power module has reached thermal limit.	<ul style="list-style-type: none"> <li>Check for jammed or obstructed drive motors.</li> <li>Check for excessively high traction current consumption, ANALYZER -&gt; DIAGNOSTICS -&gt; TRACTION -&gt; ARM CUR over 120 Amps while driving on the level.</li> </ul>
423	LIFT UP AT CUTBACK - POWER MODULE CURRENT LIMIT	The lift up portion of the power module has reached thermal limit.	<ul style="list-style-type: none"> <li>Check for jammed or obstructed arm stack or pivot bushing.</li> <li>Check for excessively high current consumption in the pump, ANALYZER -&gt; DIAGNOSTICS -&gt; PUMP -&gt; PUMP CUR over 130 Amps with an empty deck.</li> <li>Refer to Pump Motor Electrical Evaluation in Section 4.8.</li> </ul>

### 4-4 Battery Supply

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
441	BATTERY VOLTAGE TOO LOW - SYSTEM SHUT-DOWN	The power module momentarily measured battery voltage under 14.5V between ground board J1-39 and ground board J1-40.	<ul style="list-style-type: none"> <li>Recharge batteries or check for damaged batteries.</li> <li>Check battery charger function.</li> </ul>
442	BATTERY VOLTAGE TOO HIGH - SYSTEM SHUT-DOWN	The power module momentarily measured battery voltage > 37.0V.	<ul style="list-style-type: none"> <li>May be due to improper battery charging or incorrect voltage batteries being used.</li> </ul>
443	LSS BATTERY VOLTAGE TOO HIGH	The load sensing system module momentarily measured battery voltage > 34.0V.	<ul style="list-style-type: none"> <li>May be due to improper battery charging or incorrect voltage batteries being used.</li> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>

**🔧 4-4 Battery Supply**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
444	LSS BATTERY VOLTAGE TOO LOW	The load sensing system module momentarily measured battery voltage < 9V.	<ul style="list-style-type: none"> <li>Recharge batteries or check for damaged batteries.</li> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
446	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured to be out of normal operating range by the interface PCB (<11V).	<ul style="list-style-type: none"> <li>This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection.</li> <li>Drive, Steer, and Lift Prevented</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
4421	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured by the power PCB to be more than 34V for 10uS.	<ul style="list-style-type: none"> <li>This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection.</li> <li>Drive, Steer, and Lift Prevented</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
4422	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured by the power PCB to be less than 11V for 10uS.	<ul style="list-style-type: none"> <li>This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection.</li> <li>Drive, Steer, and Lift Prevented</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>

**🔧 6-6 Communication**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
661	CANBUS FAILURE - POWER MODULE	The control system failed to receive messages from the power module.	<ul style="list-style-type: none"> <li>Check for 24V between power module 12 position connector terminal 1 and the power module B- terminal. If this is the problem, the line contactor may be cycling on and off, making a clicking noise when the machine is powered.</li> <li>Disconnect ground board J1 and power module connector. Ground board socket J1-31 to power module connector socket 10 should have continuity. Ground board socket J1-32 to power module connector socket 11 should have continuity.</li> <li>Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing.</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 6-6 Communication

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
662	CANBUS FAILURE - PLATFORM MODULE	In platform mode, the control system failed to receive messages from the platform board.	<ul style="list-style-type: none"> <li>• Turn on machine in ground mode. If DTC 661 is not present check for 24V between platform box connector terminals D and A. If not 24V, test continuity from platform box connector socket A to ground board connector socket J1-6 and test continuity from platform box connector socket D to ground board connector socket J1-7.</li> <li>• If DTC 661 was present in the previous check, disconnect armstack passthru connector located near the ladder on the left. Turn on in ground mode. If DTC 661 is not present then there is a problem in armstack harness. Armstack passthru socket 5 to platform box terminal E should have continuity. Armstack passthru socket 6 to platform box connector terminal F should have continuity. Armstack passthru socket 7 to platform box connector terminal G should have continuity. Armstack passthru socket 5 to armstack passthru socket 6 resistance should be 120 Ohms +/- 5%. Armstack passthru socket 5 to armstack passthru socket 7 should measure open circuit. Armstack passthru socket 6 to armstack passthru socket 7 should measure open circuit.</li> <li>• Disconnect armstack passthru and ground board J1. Armstack passthru pin 5 to ground board socket J1-11 should have continuity. Armstack passthru pin 6 to ground board socket J1-12 should have continuity. Armstack passthru pin 7 to ground board socket J1-13 should have continuity. Armstack passthru pin 5 to armstack passthru pin 6 should measure open circuit. Armstack passthru pin 5 to armstack passthru pin 7 should measure open circuit. Armstack passthru pin 6 to armstack passthru pin 7 should measure open circuit.</li> <li>• Disconnect ground board J1 and power module connector. Ground board socket J1-31 to power module connector socket 10 should have continuity. Ground board socket J1-32 to power module connector socket 11 should have continuity. Ground board socket J1-31 to J1-32 should measure open circuit. Ground board socket J1-31 to J1-33 should measure open circuit. Ground board socket J1-32 to J1-33 should measure open circuit.</li> <li>• Ensure all connections opened above are reconnected. Disconnect power module connector. Turn on in platform mode. If DTC 662 is no longer present replace power module.</li> <li>• If DTC 661 and 662 have been present through above steps replace ground board.</li> </ul> <p style="text-align: right;"><i>Continued Next Page</i></p>



** 6-6 Communication**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
662 (Cont.)	CANBUS FAILURE - PLATFORM MODULE (Continued)	In platform mode, the control system failed to receive messages from the platform board.	<ul style="list-style-type: none"> <li>Disconnect platform box connector. Open platform box. Disconnect platform board connector. Platform box socket E to platform board J1-3 should have continuity. Platform box socket F to platform board J1-4 should have continuity. Platform box pin E to pin F should measure open circuit. Platform box pin E to pin G should measure open circuit. Platform box pin F to pin G should measure open circuit. If these checks are OK replace platform board.</li> </ul>
663	CANBUS FAILURE - LOAD SENSING SYSTEM MODULE	With load sensing system enabled, the control system failed to receive messages from the load sensing system module.	<ul style="list-style-type: none"> <li>Check ANALYZER -&gt; MACHINE SETUP -&gt; MODEL NUMBER is correct.</li> <li>Check ANALYZER -&gt; MACHINE SETUP -&gt; MARKET is correct.</li> <li>Check ANALYZER -&gt; MACHINE SETUP -&gt; LOAD is correct.</li> <li>Check for 24V between load sense system module connector J1-1 and J1-2.</li> <li>Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing.</li> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
664	CANBUS FAILURE - ACCESSORY MODULE	An accessory module has stopped communication.	<ul style="list-style-type: none"> <li>Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing.</li> <li>See accessory module documentation for troubleshooting.</li> </ul>
6635	CANBUS FAILURE - CHASSIS TILT SENSOR	Chassis Tilt Sensor messages not received for 1000 mS while B+ is present on J1-28	<ul style="list-style-type: none"> <li>The control system failed to receive messages from the Chassis Tilt Sensor located inside the Ground Control Box.</li> <li>Ensure that +B is present on pin 1 of the sensor, and -B is present on pin 4. Check the CANbus wiring to pins 2 and 3 of the sensor.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>

** 6-7 Accessory**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
671	ACCESSORY FAULT	An accessory module is reporting a fault.	<ul style="list-style-type: none"> <li>See accessory module documentation for troubleshooting.</li> </ul>

** 7-7 Electric Motor**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
771	OPEN CIRCUIT DRIVE MOTOR WIRING	The power module detected a problem in the drive motors' power circuit wiring.	<ul style="list-style-type: none"> <li>Refer to Drive Motor Electrical Evaluation in Section 3.5.</li> <li>Refer to Power Module Electrical Evaluation in Section 3.6.</li> </ul>
772	STALLED TRACTION MOTOR OR POWER WIRING ERROR	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>The System Module detected armature current feedback &gt; 4.5V or &lt; 0.5V. This is mostly likely caused by a stalled traction motor or power wiring issue. Alternately, it could be an internal fault.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 7-7 Electric Motor

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
773	CAPACITOR BANK FAULT - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• There is an internal or external fault that prevents the System Module's capacitor bank from charging.</li> <li>• The System Module detected that the VMN of the pump and traction has not increased more than 1.3V in 1000mS. Alternately, the VMN of the pump or traction is less than 20% of battery voltage.</li> <li>• If this message persists after disconnecting the drive and pump wiring, there is an internal fault.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
774	SHORT CIRCUIT FIELD WIRING	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• The field wiring passed System Module power-up diagnostics. However, an external short circuit was detected when current was applied to F1 / F2. This situation is caused by improper field wiring or a damaged motor.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul> <p><b>NOTE:</b> <i>Tilt Sensor Calibration is not available when this condition is present.</i></p>
775	OPEN CIRCUIT FIELD WIRING	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• The System Module applied field current, but could not regulate the desired current. The situation is caused by improper field wiring or a damaged motor.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
776	STALLED PUMP MOTOR OR POWER WIRING ERROR	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• The System Module measured improper pump current feedback (&gt;4.5V or &lt;0.5V) for 240mS. This is caused by a stalled pump motor, a power wiring issue, or a System Module malfunction.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
777	OPEN CIRCUIT PUMP MOTOR WIRING	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• The System Module measured pump current less than 8A while the motor voltage was greater than 7V for 1200mS. This indicates there is an open-circuit between the System Module's -P terminal and the pump motor.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
778	TRACTION T HIGH - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• While driving, the voltage measured at the System Module's T terminal did not agree with the predicted value for at least 300mS. This issue may be caused by a power wiring error or an internal fault.</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>
779	TRACTION T LOW - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>• While driving, the voltage measured at the System Module's T terminal did not agree with the predicted value for at least 1000mS. This issue may be caused by an open circuit of the armature wiring (+B and -T terminals) or an internal fault.</li> <li>• VMN does not increase more than 1.3V</li> <li>• VMN is less than 20% Battery Voltage</li> <li>• Battery Voltage . VMN is greater than 4V</li> <li>• ZAPI - HEALTH (Status LED) - ON</li> </ul>

 **7-7 Electric Motor**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
7710	PUMP P HIGH - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>While steering or lifting up, the voltage measured at the System Module's P terminal did not agree with the predicted value for at least 240mS. This issue may be caused by a power wiring error or an internal fault.</li> <li>Pump Feedback . Predicted &gt;7V</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
7711	PUMP P LOW - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>While steering or lifting up, the voltage measured at the System Module's P terminal did not agree with the predicted value for at least 1000mS. This issue may be caused by an open-circuit of the pump wiring (+BF2 and -P terminals) or an internal fault.</li> <li>Pump feedback does not increase more than 1.3V</li> <li>Pump feedback is less than 20% Battery Voltage</li> <li>Battery Voltage - pump feedback is greater than 4V</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
7741	ARMATURE BRAKING CURRENT TOO HIGH	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>The System Module detected excessive braking current for more than 5000mS. This can be caused by transporting an excessive load on a steep grade. Alternately, this may indicate an internal fault.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
7742	FIELD VOLTAGE IMPROPER	Drive, Steer, and Lift Prevented	<ul style="list-style-type: none"> <li>The System Module voltage at the F1 and F2 terminals was improper at power-up (expected to be ½ Battery Voltage). This is caused by an open- or short-circuit in the field wiring or motor. Disconnect the field and motor wiring from the System Module and connect F1 / F2 with a short wire. If the situation persists after a power cycle, it may be an internal issue.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>

 **8-1 Tilt Sensor**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
811	TILT SENSOR NOT CALIBRATED	The tilt sensor calibration has not been performed.	<ul style="list-style-type: none"> <li>Calibrate the tilt sensor, see Section 5.2.</li> <li>Replace then calibrate tilt sensor, see Section 5.2.</li> </ul>
812	NO DATA FROM TILT SENSOR - NOT CONNECTED OR FAULTY	No signal from tilt sensor.	<ul style="list-style-type: none"> <li>Check tilt sensor connections and wiring in ground control box.</li> <li>Calibrate the tilt sensor, see Section 5.2.</li> <li>Replace then calibrate tilt sensor, see Section 5.2.</li> </ul>

**NOTE:** Tilt Sensor cannot be calibrated if main contactor is open due to an alarm.

 **8-2 Platform Load Sense**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
821	LSS CELL #1 ERROR	A problem has been detected with the load sense system.	Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
822	LSS CELL #2 ERROR	A problem has been detected with the load sense system.	Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
823	LSS CELL #3 ERROR	A problem has been detected with the load sense system.	Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 8-2 Platform Load Sense

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
824	LSS CELL #4 ERROR	A problem has been detected with the load sense system.	<ul style="list-style-type: none"> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
825	LSS HAS NOT BEEN CALIBRATED	The load sensing system module has not been calibrated	<ul style="list-style-type: none"> <li>Empty platform. Calibrate LSS, see Section 2.2: Calibration in the LSS manual, 3124288.</li> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>

### 9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
991	LSS WATCHDOG RESET	A problem has been detected with the load sense system.	<ul style="list-style-type: none"> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
992	LSS EEPROM ERROR	A problem has been detected with the load sense system.	<ul style="list-style-type: none"> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
993	LSS INTERNAL ERROR - PIN EXCITATION	A problem has been detected with the load sense system.	<ul style="list-style-type: none"> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
994	LSS INTERNAL ERROR - DRDY MISSING FROM A/D	A problem has been detected with the load sense system.	<ul style="list-style-type: none"> <li>Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.</li> </ul>
995	POWER MODULE FAILURE - PERSONALITY RANGE ERROR	The power module detected an out-of-range or corrupt personality setting	<ul style="list-style-type: none"> <li>Record all personality settings in ANALYZER -&gt; PERSONALITIES and ANALYZER -&gt; MACHINE SETUP. Reset control system personalities to default settings by selecting a different model than indicated, cycle power then select proper model. Then, enter personality settings recorded above.</li> </ul>
996	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's analog to digital converter does not respond for the power PCB. This is an internal failure.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
997	POWER MODULE FAILURE - CHECK POWER CIRCUITS OR MOSFET SHORT CIRCUIT	The power module detected an error in the power wiring for the drive or pump.	<ul style="list-style-type: none"> <li>Refer to Drive Motor Electrical Evaluation in Section 3.5.</li> <li>Refer to Pump Motor Electrical Evaluation in Section 4.8.</li> <li>Refer to Power Module Electrical Evaluation in Section 3.6.</li> </ul>
998	EEPROM FAILURE - CHECK ALL SETTINGS	The control system detected an EEPROM failure.	<ul style="list-style-type: none"> <li>Replace ground board.</li> </ul>
999	FUNCTION LOCKED OUT - POWER MODULE SOFTWARE VERSION IMPROPER	The power module software version is not compatible with the rest of the system.	<ul style="list-style-type: none"> <li>Replace power module to clear fault.</li> </ul>
9910	FUNCTION LOCKED OUT - PLATFORM MODULE SOFTWARE VERSION IMPROPER	The platform board software version is not compatible with the rest of the system.	<ul style="list-style-type: none"> <li>Reprogram platform board.</li> </ul>

** 9-9 Hardware**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
9911	FUNCTION LOCKED OUT - LSS MODULE SOFTWARE VERSION IMPROPER	The load sensing system module software version is not compatible with the rest of the system.	<ul style="list-style-type: none"> <li>Replace LSS module to clear fault.</li> </ul>
9912	POWER MODULE FAILURE - SYSTEM MONITOR	The ground board detected armature, field, or pump current while function was not commanded.	<ul style="list-style-type: none"> <li>Refer to Drive Motor Electrical Evaluation in Section 3.5.</li> <li>Refer to Pump Motor Electrical Evaluation in Section 4.8.</li> <li>Refer to Power Module Electrical Evaluation in Section 3.6.</li> </ul>
9917	HIGH RESOLUTION ANALOG TO DIGITAL FAILURE - INTERRUPT LOST	The ground board detected armature, field, or pump current while function was not commanded.	<ul style="list-style-type: none"> <li>Pump Motor being turned backwards by a faulty check valve in the hydraulic system.</li> <li>Software issue on the controller. Update software.</li> </ul>
9924	FUNCTIONS LOCKED OUT - MACHINE NOT CONFIGURED	The control system's memory indicates that the vehicle has not been configured (new control system components).	<ul style="list-style-type: none"> <li>Use the JLG analyzer to adjust all machine setup and personality settings, refer to 5.7 Machine Configuration Programming Information.</li> </ul>
9950	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's armature power circuitry is driven without PWM command for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9951	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's pump power circuitry is driven without enable from the interface PCB for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9952	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's pump power circuitry is driven without PWM command for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9953	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's field power circuitry is driven without enable from the interface PCB for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9954	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's field power circuitry is driven without reverse direction from the power PCB for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9955	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's field power circuitry is driven without forward selection from the power PCB for 100mS.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>

## SECTION 6 - DIAGNOSTIC TROUBLE CODES

### 9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
9956	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's field current control or MOSFET's are malfunctioning.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9957	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's hardware that generates an interrupt at 36V and 12V did not respond properly at power-up.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9958	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's pump current measurement or MOSFET are malfunctioning.</li> <li>Pump current measurement &gt;2.74V or &lt;2.26V for 200mS while idle.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9960	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module detected an issue with the traction current measurement or the MOSFET's.</li> <li>Armature current feedback &gt;2.74V or &lt; 2.26V while idle</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9962	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's temperature feedback is &gt;4.9V or &lt;0.1V.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9963	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module detected a mismatch in the redundant RAM information stored in the power PCB.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
9964	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's analog to digital converter does not respond for the interface PCB.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
9969	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's MC/EB/EV/DV Enable is always on. This is internal fault.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>

 **9-9 Hardware**

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
9970	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module detected a mismatch in the redundant RAM information stored in the interface PCB.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - ON</li> </ul>
9971	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's MC/EB valve activation pin is shorted. This is an internal fault.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99143	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's power and interface PCB digital inputs do not agree.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99144	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's MC feedback from the interface PCB disagrees with the feedback from the power PCB.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99145	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's enable for the power PCB requested a drive motor or valve activation when not expected.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99146	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's lift down feedback voltage to the interface and power PCB's disagrees.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99147	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's VMN feedback voltage to the interface and power PCB's disagrees.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99148	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module's setpoint request from the interface PCB does not match the input state.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>
99149	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	<ul style="list-style-type: none"> <li>The System Module encountered an unexpected software issue.</li> <li>Cycle machine, if error still exists, replace System Module.</li> <li>ZAPI - HEALTH (Status LED) - FLASHING</li> </ul>





## SECTION 7. GENERAL ELECTRICAL INFORMATION & SCHEMATICS

### 7.1 GENERAL

This section contains schematics to be used for locating and correcting most of the operating problems which may develop. 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 INCHES (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.**

### 7.2 MULTIMETER BASICS

A wide variety of multimeters 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.

#### **Backprobing**

To "backprobe" 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 backprobing 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)

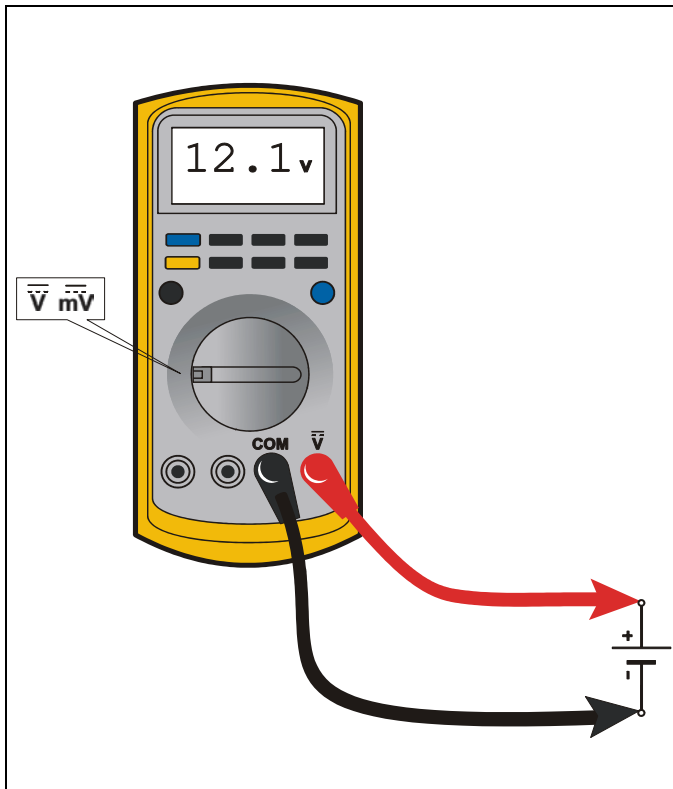
m = milli = (Displayed Number) / 1,000

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

Example: 1.2 kΩ = 1200 Ω

Example: 50 mA = 0.05 A

Voltage Measurement



Resistance Measurement

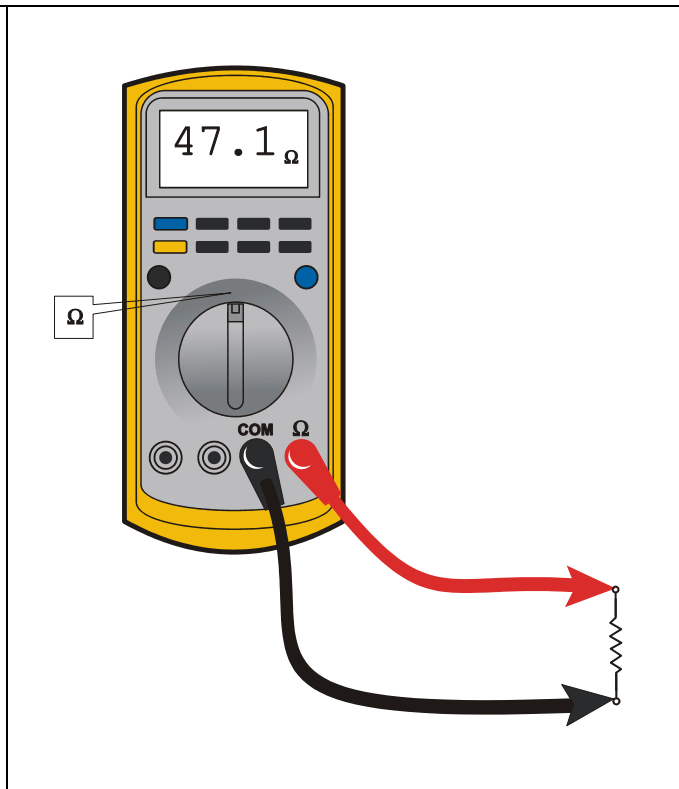


Figure 7-1. Voltage Measurement (DC)

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

Figure 7-2. 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

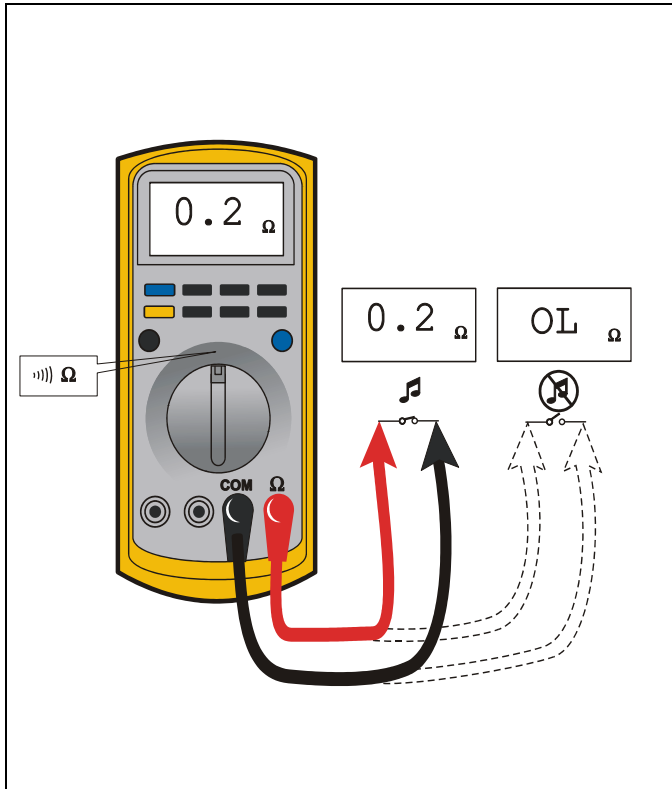


Figure 7-3. Continuity Measurement

- 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

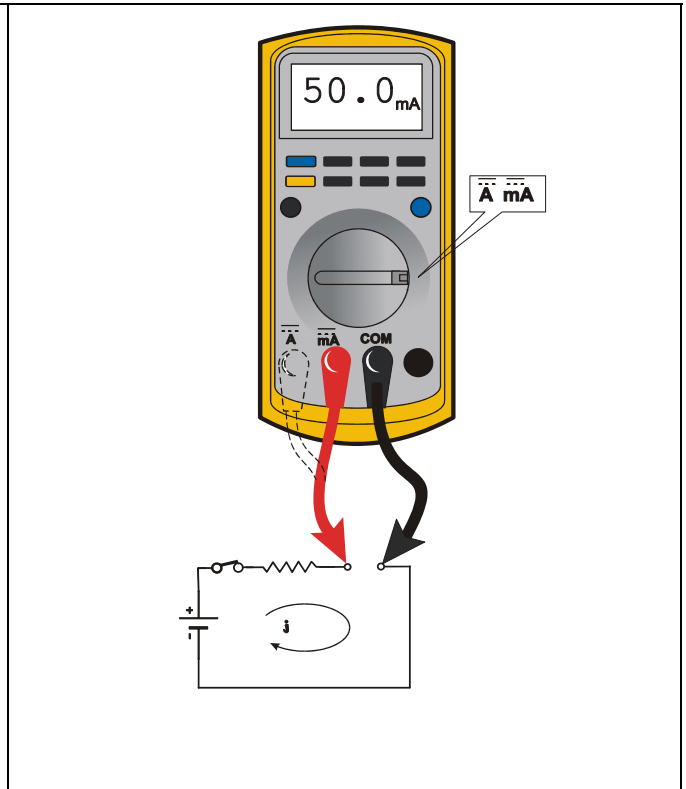


Figure 7-4. Current Measurement (DC)

- 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 multi meter'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.

### 7.3 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.

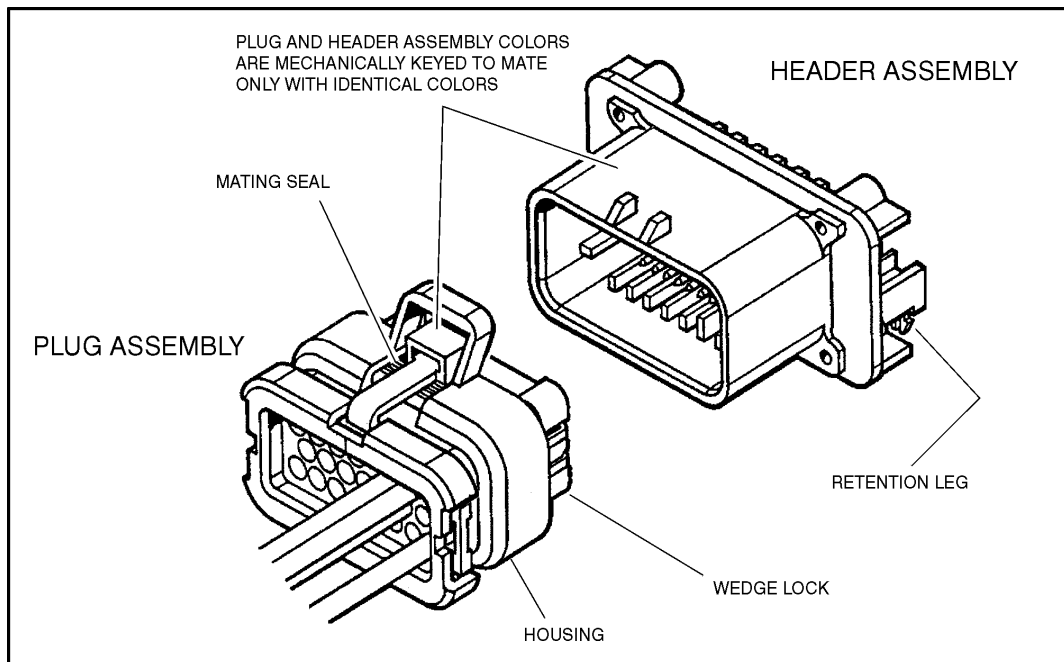
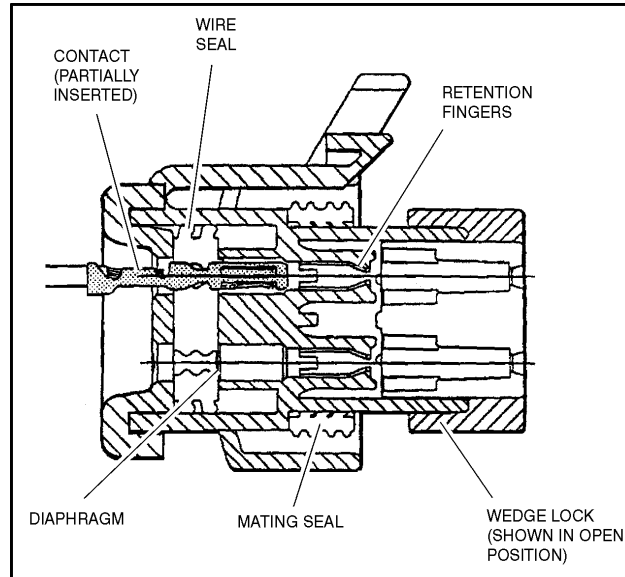


Figure 7-5. AMP Connector

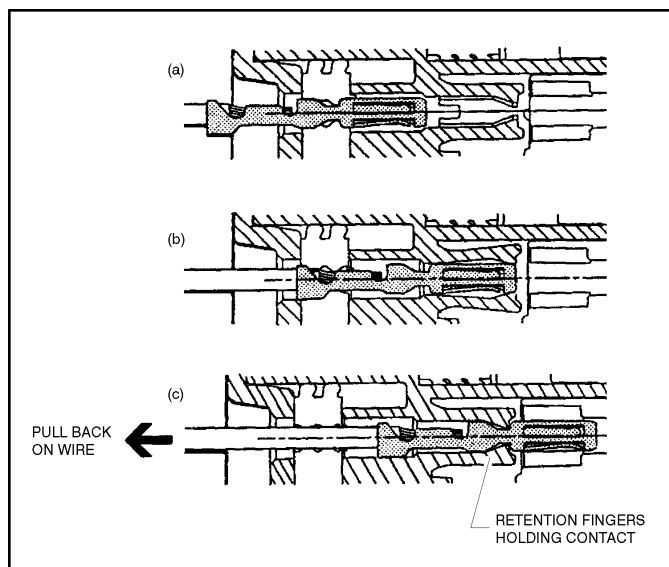
### Assembly

Check to be sure the wedge lock is in the open, or as-shipped, position (See Figure 7-6. Connector Assembly (1 of 4)). Proceed as follows:



**Figure 7-6. Connector Assembly (1 of 4)**

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it will go (See Figure 7-7. Connector Assembly (2 of 4)).
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 (See Figure 7-7. Connector Assembly (2 of 4)).
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 (See Figure 7-8. Connector Assembly (3 of 4)).
4. Slide the wedge lock into the housing until it is flush with the housing (See Figure 7-9. Connector Assembly (4 of 4)).



**Figure 7-7. Connector Assembly (2 of 4)**

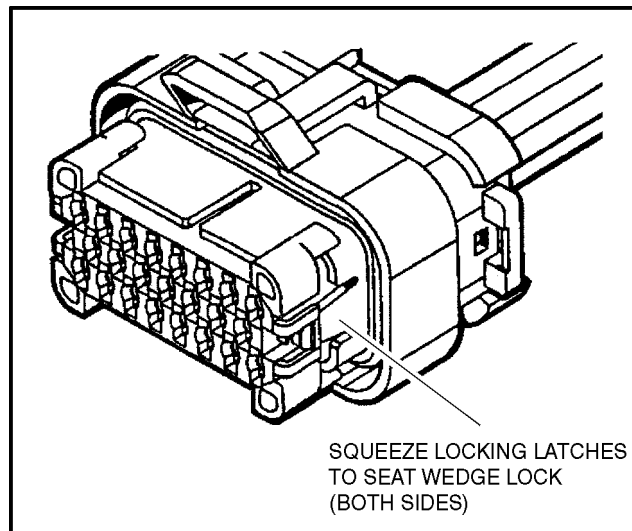


Figure 7-8. Connector Assembly (3 of 4)

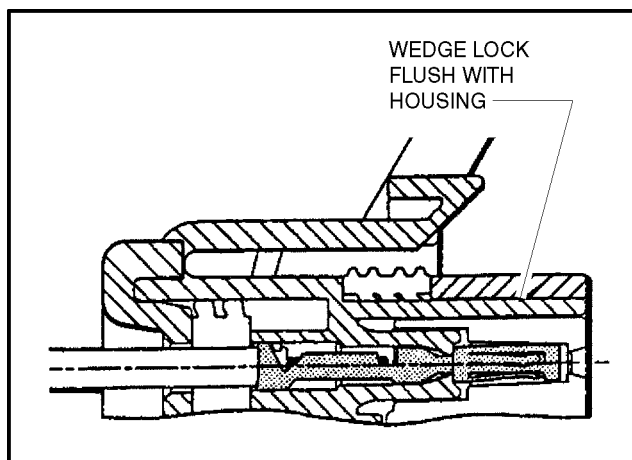
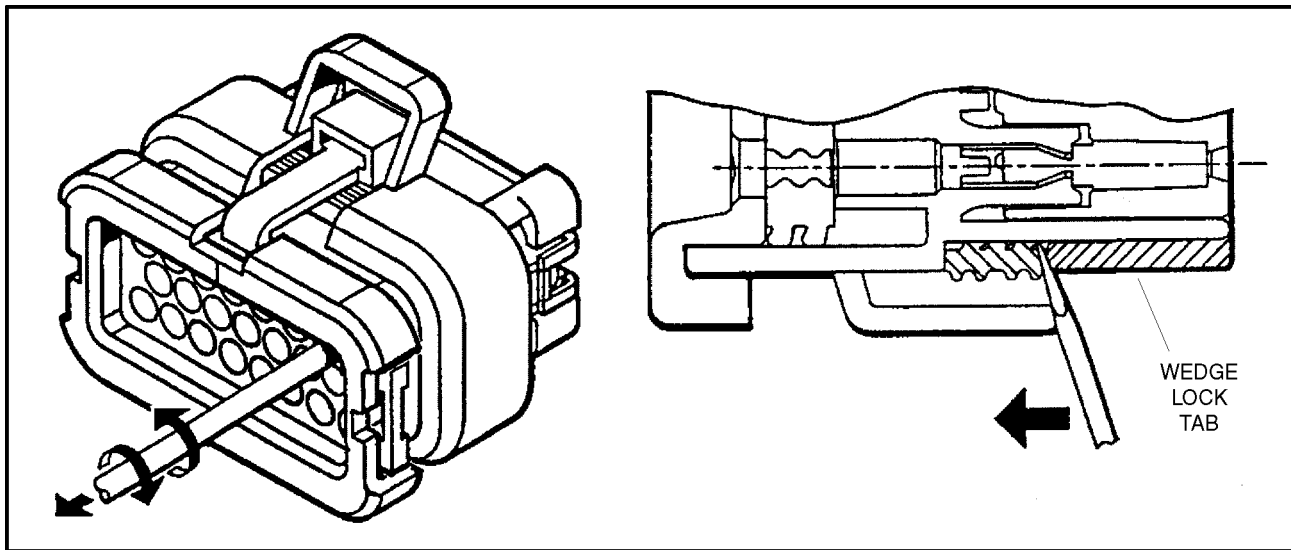


Figure 7-9. Connector Assembly (4 of 4)

### Disassembly

5. Insert a 4.8 mm (3/16") wide screwdriver blade between the mating seal and one of the red wedge lock tabs.
6. Pry open the wedge lock to the open position.
7. 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.



**Figure 7-10. Connector Disassembly**

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

### **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.

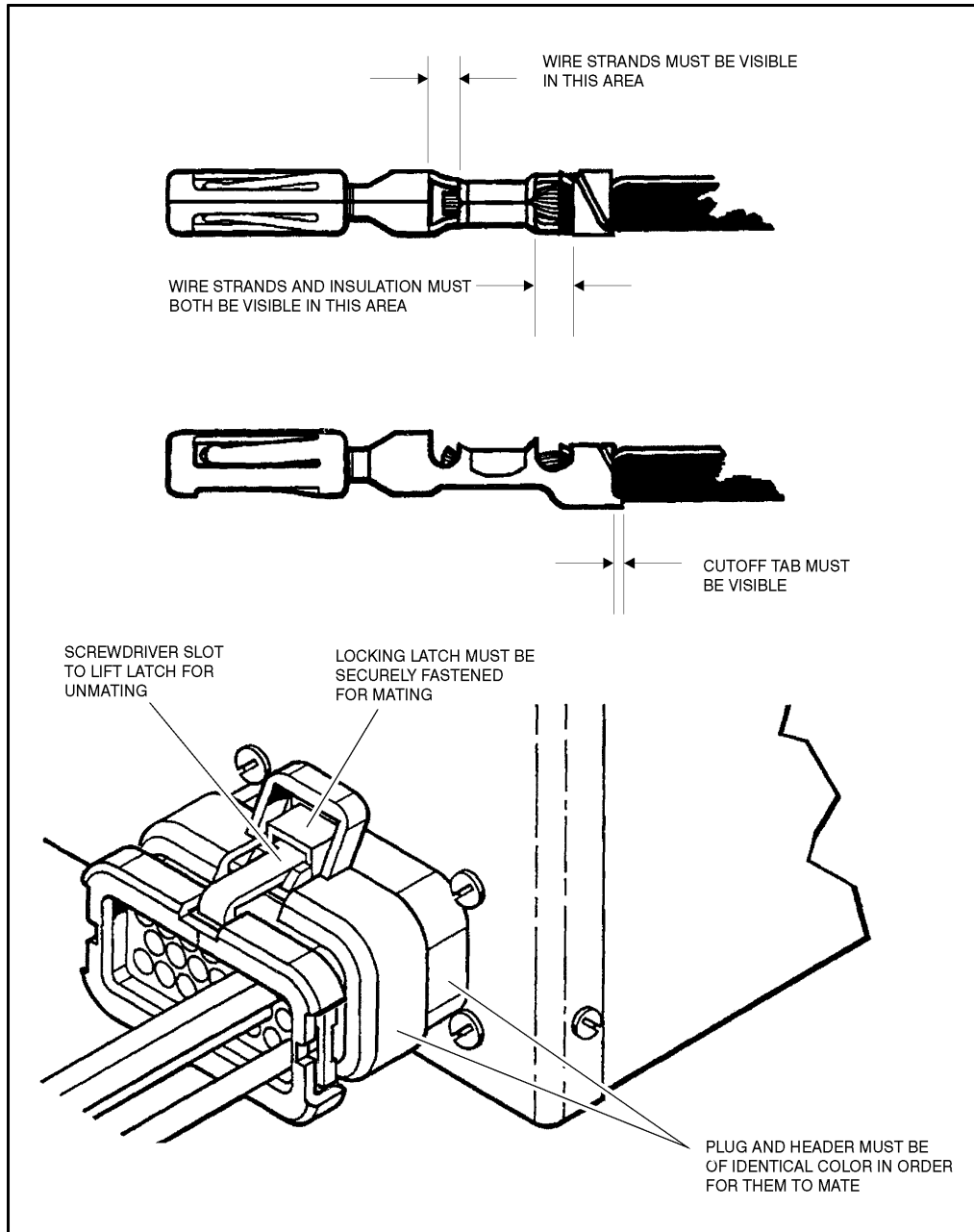


### Service - Voltage Reading



**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 7-11. Connector Installation**

## 7.4 WORKING WITH DEUTSCH CONNECTORS

### DT/DTP Series Assembly



Figure 7-12. DT/DTP Contact Installation

1. Grasp crimped contact about 25mm 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 7-13. DT/DTP Contact Removal

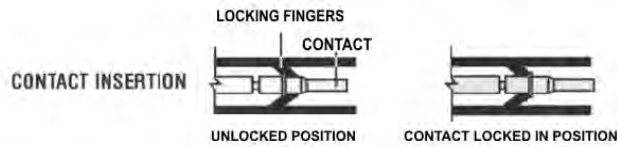
5. Remove wedgelock using needlenose pliers or a hook shaped wire to pull wedge straight out.
6. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.
7. Hold the rear seal in place, as removing the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

### HD30/HDP20 Series Assembly



Figure 7-14. HD/HDP Contact Installation

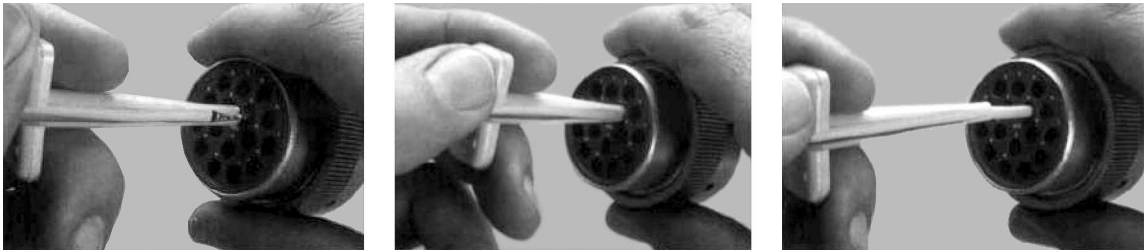
8. Grasp contact about 25mm behind the contact crimp barrel.
9. Hold connector with rear grommet facing you.
10. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm that it is properly locked in place.



**Figure 7-15. HD/HDP Locking Contacts Into Position**

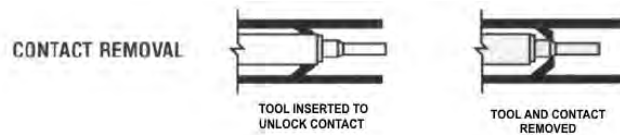
**NOTE:** For unused wire cavities, insert sealing plugs for full environmental sealing

### HD30/HDP20 Series Disassembly



**Figure 7-16. HD/HDP Contact Removal**

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



**Figure 7-17. HD/HDP Unlocking Contacts**

**NOTE:** Do Not twist or insert tool at an angle.

### 7.5 SWITCHES

#### 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 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.

#### 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.

## 7.6 CIRCUIT BOARDS: INPUTS AND OUTPUTS

**Table 7-1. Ground Board J1 (1600346 Power Module ONLY)**

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Analyzer Power	Power Output	12
3	RS-232 Receive	Input/Output	Comm
4	RS-232 Transmit	Input/Output	Comm
5	Platform EMS	Input	Vbatt
6	Ground	Power Output	0
7	Ignition	Power Output	Vbatt
8	Platform EMS Source	Power Output	Vbatt
9	Ignition	Power Output	Vbatt
10	Left PHP Switch	Input	Vbatt
11	CAN Bus high	Input/Output	Comm
12	CAN Bus Low	Input/Output	Comm
13	CAN Bus Shield	Power Output	0
14	Analog Power	Power Output	5
15	Elevation Angle Sensor	Input	5
16	Ground	Power Output	0
17	Ignition	Power Output	Vbatt
18	Right PHP Switch	Input	Vbatt
19	Ignition	Power Output	Vbatt
20	Brake Release Swtich	Input	Vbatt
21	Steer Left Coil	Output	Vbatt
22	Steer Right Coil	Output	Vbatt
23	Left Brake Release	Output	Vbatt
24	Right Brake Release	Output	Vbatt
25	Lift Up Coil	Output	Vbatt
26	Lift Down Coil	Output	PWM
27	Ground	Power Output	0
28	Ground Alarm	Output	PWM
29	Charger Interlock	Input	Vbatt
30	Ground	Power Output	0
31	CAN Bus High	Input/Output	Comm

## SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

**Table 7-1. Ground Board J1 (1600346 Power Module ONLY)**

Pin	Function	Type	Range (V)
32	CAN Bus Low	Input/Output	Comm
33	CAN Bus Shield	Output	0
34	CAN Bus High	Input/Output	Comm
35	CAN Bus Low	Input/Output	Comm
36	CAN Bus Shield	Output	0
37	Ground	Power Output	0
38	Ground Enable	Power Output	0
39	Master Ignition Connection	Power Input	Vbatt
40	Master Ground Connection	Power Input	0

**Table 7-2. Ground Board J2**

Pin	Function	Type	Range (V)
1	Ignition	Power Output	Vbatt
2	Ground EMS	Power Input	Vbatt
3	Platform EMS Source	Power Input	Vbatt
4	Ground Mode Select	Input	Vbatt
5	Ground	Power Output	0
6	Ground Lift Up	Input	Vbatt
7	Ground Lift Down	Input	Vbatt
8	Hour Meter	Output	Vbatt
9	Ground Overload Lamp	Output	Vbatt

**Table 7-3. Ground Board J3**

Pin	Function	Type	Range (V)
1	Tilt Sensor Power	Power Output	12
2	Tilt Sensor X-Axis (PWM)	Input	12
3	Tilt Sensor Y-Axis (PWM)	Input	12
4	Ground	Power Output	0

## SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

**Table 7-4. Platform Board J1**

Pin	Function	Type	Range (V)
1	Master Ignition	Power Input	Vbatt
2	Master Ground	Power Input	0
3	CAN Bus High	Input/Output	Comm
4	CAN Bus Low	Input/Output	Comm
5	Joystick Power Supply	Power Output	5
6	Joystick Signal	Input	5
7	Ground	Power Output	0
8	Trigger Switch	Input	Vbatt
9	Lift Select Switch (Active Low)	Input	Vbatt
10	Drive Select Switch (Active Low)	Input	Vbatt
11	Ground	Power Output	0
12	Platform Alarm (Active Low)	Output	Vbatt
13	Indoor/Outdoor Select Swtich	Power Output	Vbatt
14	Horn Switch	Power Output	Vbatt
15	Steer Left Switch	Input	Vbatt
16	Steer Right Switch	Input	Vbatt

**Table 7-5. Platform Board J3**

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Swtich Shield (Grounded)	Output	0
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Indoor/Outdoor Select Switch (Active Low)	Input	Vbatt

**Table 7-6. Platform Board J4**

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Switch Shield (Ground)	Power Output	0
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Horn Switch (Active Low)	Input	Vbatt

## SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

**Table 7-7. Power Module (1600346 Power Module ONLY)**

Pin	Function	Type	Range (V)
1	Ignition	Power Input	Vbatt
2	Not Used	--	--
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Not Used	--	--
8	Line Contactor High Side	Power Output	Vbatt
9	Not Used	--	--
10	CAN Bus High	Input/Output	Comm
11	CAN Bus Low	Input/Output	Comm
12	Not Used	--	--

**Table 7-8. Power Module - J1 (1001092456 Power Module ONLY)**

Pin	Function	Type	
1	Primary Elevation Sensor Analog Input (0-5V)	Analog	Input
2	Spare - Analog Input	Analog	Input
3	Control for Ground Alarm (PWM)	Digital	Output
4	Positive for Analyzer (+12V)	Power	Output
5	Ground Select (Logic Supply for Ground Mode)	Power	Input
6	Positive for Tilt Sensor (Connect to +BATT)	Power	Output
7	Positive for Ground Alarm (Connect to +BATT)	Power	Output
8	Ground Lift Up Switch (High-Sensing)	Digital	Input
9	Right Pothole Switch (High-Sensing)	Digital	Input
10	Ground Lift Down Switch (High-Sensing)	Digital	Input
11	Left Pothole Switch (High-Sensing)	Digital	Input
12	Spare Negative Reference	Power	Output
13	Positive Main Line Contactor (Connect to GNDS diode OR'd with EMS)	Power	Output
14	Spare Digital Input (High-Sensing)	Digital	Input
15	Spare Digital Input (High-Sensing)	Digital	Input
16	Positive Rotary Sensor Reference (+5V)	Power	Output
17	Negative for Rotary Sensor	Power	Output
18	Positive Left Pothole Switch Reference (Connect to +BATT)	Power	Output
19	Positive Right Pothole Switch Reference (Connect to +BATT)	Power	Output
20	RS-232 Receive	Serial	Input
21	RS-232 Transmit	Serial	Output
22	Negative for Analyzer (Connect to -B)	Power	Output
23	Spare Negative Reference (Connect to -B)	Power	Output
24	Spare Digital Input (High-Sensing)	Digital	Input



## SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

**Table 7-8. Power Module - J1 (1001092456 Power Module ONLY)**

Pin	Function	Type	
25	Elevation Proximity Switch (High-Sensing; 1230ES only)	Digital	Input
26	Charger Interlock (High-Sensing)	Digital	Input
27	Foot Switch (High-Sensing; 1230ES only)	Digital	Input
28	Battery Supply from External Relay	Power	Input
29	Positive Left Brake Release (Connect to +BATT)	Power	Output
30	Positive Right Brake Release (Connect to +BATT)	Power	Output
31	Positive Manual Brake Release (Connect to +BATT)	Power	Output
32	Negative Main Line Contactor (Low-Side Driver)	Digital	Output
33	Negative Right Brake Solenoid (Low-Side Driver)	Digital	Output
34	Negative Left Brake Solenoid (Low-Side Driver)	Digital	Output
35	Spare Digital Output (Low-Side Driver) / Digital Input (High-Sensing)	Digital	Output

**Table 7-9. Power Module - J2 (1001092456 Power Module ONLY)**

Pin	Function	Type	
1	Spare - (Connect to +BATT)	Power	Output
2	Positive Lift Down Valve (High-Side Driver)	Power	Output
3	Spare Digital Input (High-Sensing)	Digital	Input
4	Spare Digital Input (High-Sensing)	Digital	Input
5	CANbus Low	Serial	I/O
6	CANbus High	Serial	I/O
7	Spare Positive Analog Reference (+5V)	Power	Output
8	Platform EMS (Logic Supply for Platform Mode)	Power	Input
9	Negative Steer Left Solenoid Valve (Low-Side Driver)	Digital	Output
10	Switch Manual Brake Release (High-Sensing)	Digital	Input
11	Spare Digital Input (High-Sensing)	Digital	Input
12	Spare Digital Input (High-Sensing)	Digital	Input
13	Spare Digital Input (High-Sensing)	Digital	Input
14	Spare Negative Analog Reference (Connect to -B)	Power	Output
15	CANbus Shield (Connect to -B)	Power	Output
16	Negative Lift Down Valve (Low-Side Driver)	Power	Output
17	Negative Lift Up Solenoid Valve (Low-Side Driver)	Digital	Output
18	Negative Steer Right Solenoid Valve (Low-Side Driver)	Digital	Output
19	Spare Analog Input (0-5V)	Analog	Input
20	Spare Digital Output (Low-Side Driver)	Digital	Output
21	Spare Digital Output (Low-Side Driver)	Digital	Output
22	Negative for Overload Lamp (Low-Side Driver)	Digital	Output
23	Negative for Hourmeter (Low-Side Driver)	Digital	Output

# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

## 7.7 ELECTRICAL SCHEMATICS AND LAYOUTS

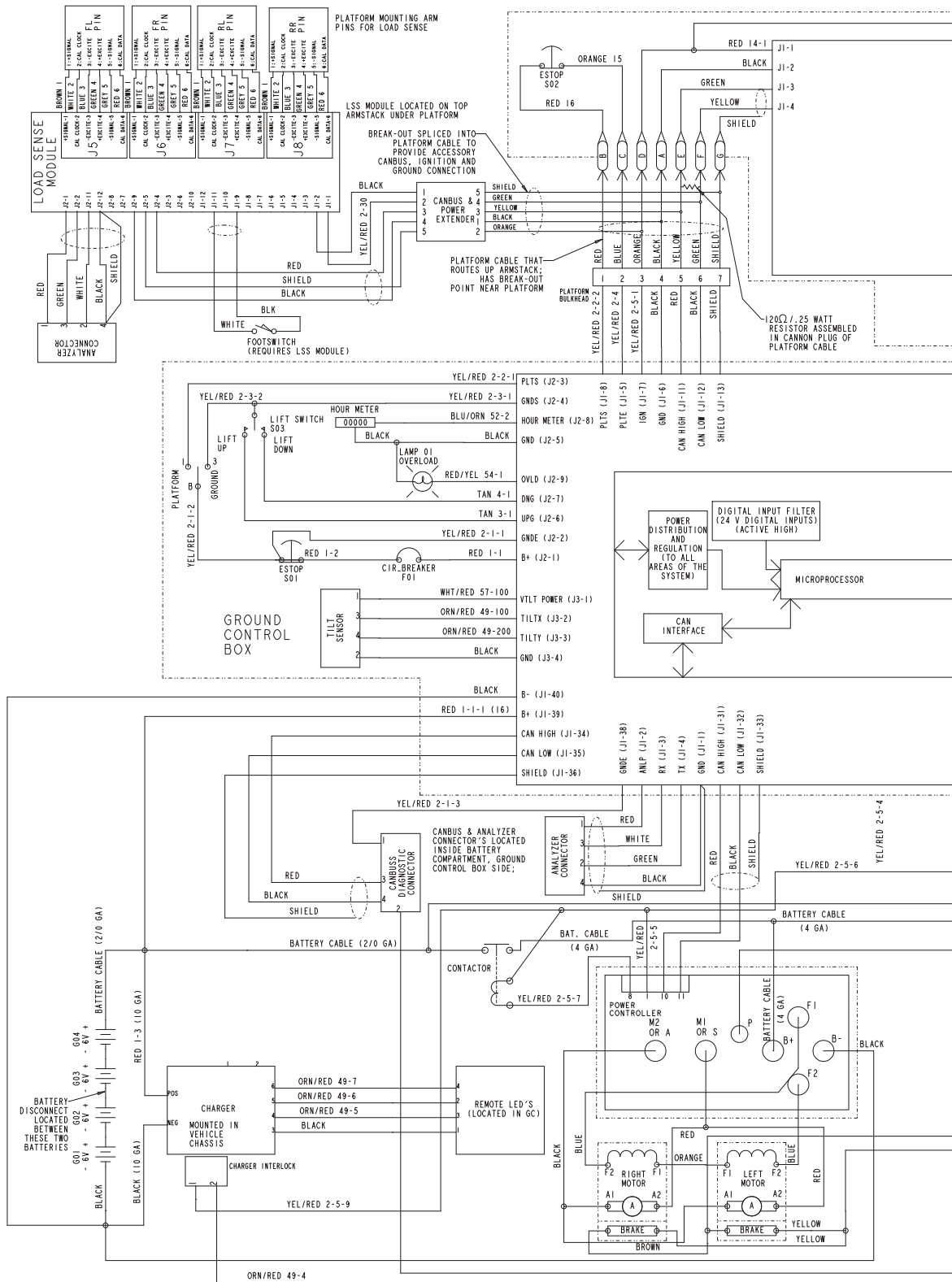
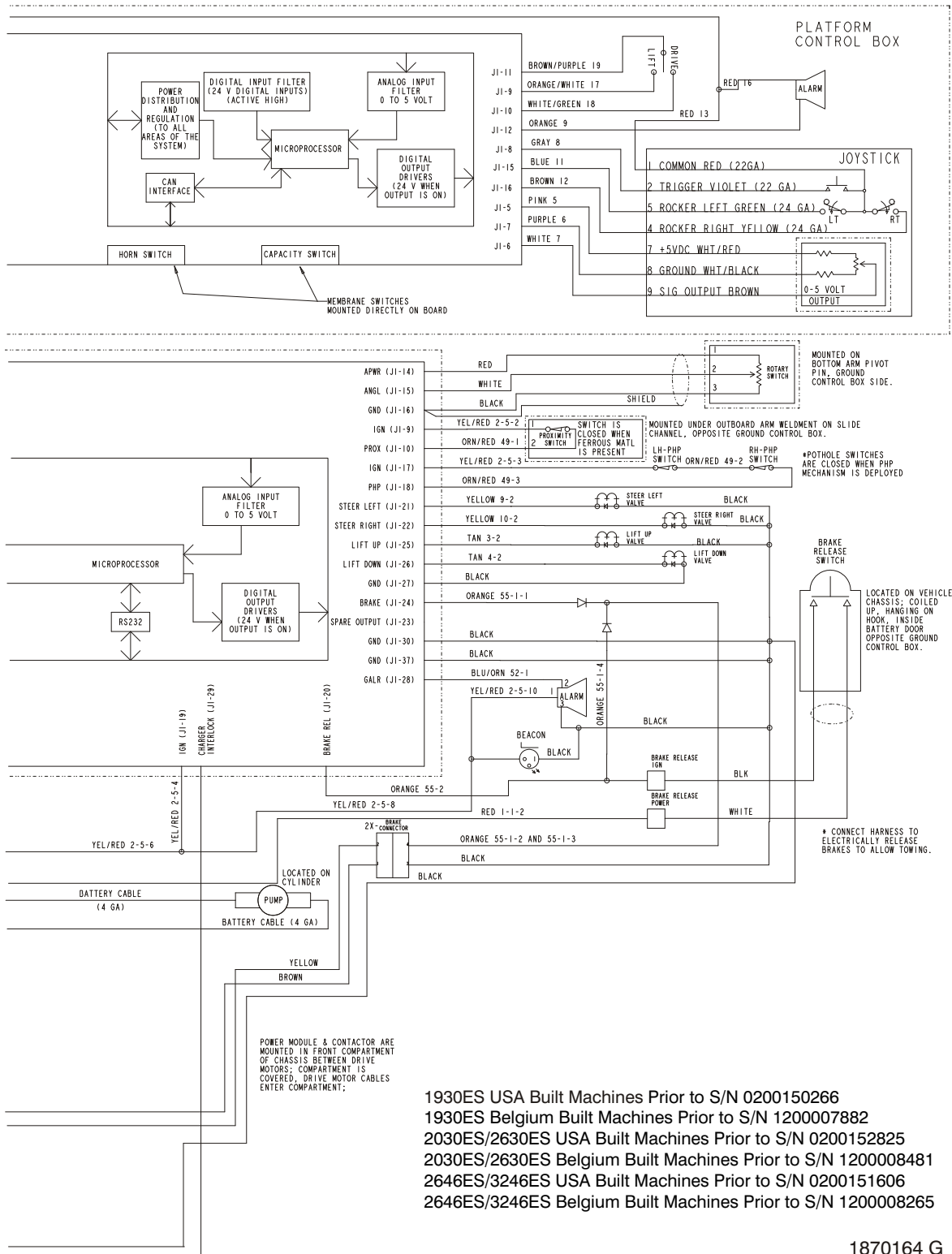


Figure 7-18. Electrical Schematic - 1870164 G - Sheet 1 of 2

# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS



**Figure 7-19. Electrical Schematic - 1870164 G - Sheet 2 of 2**

# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

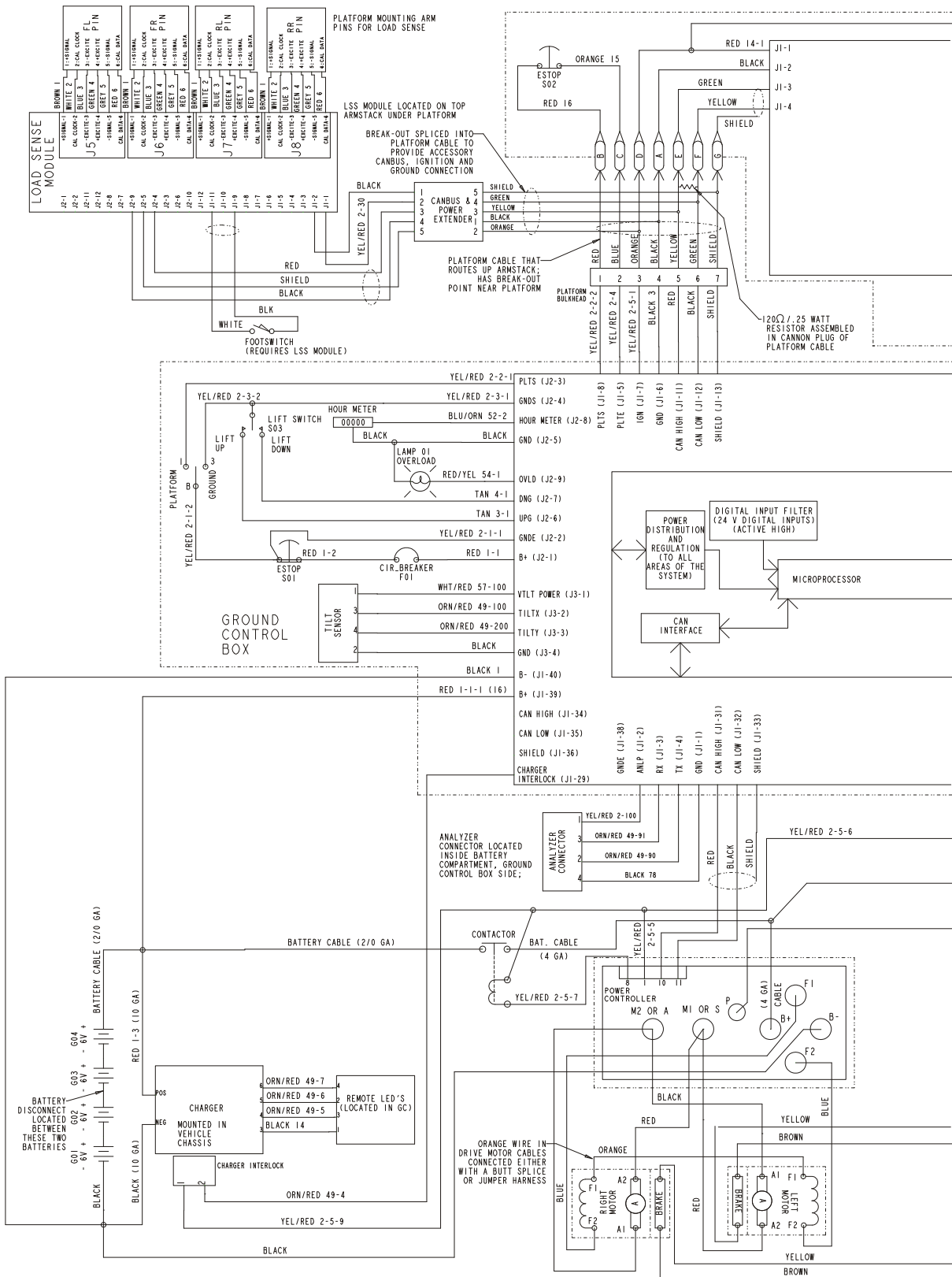
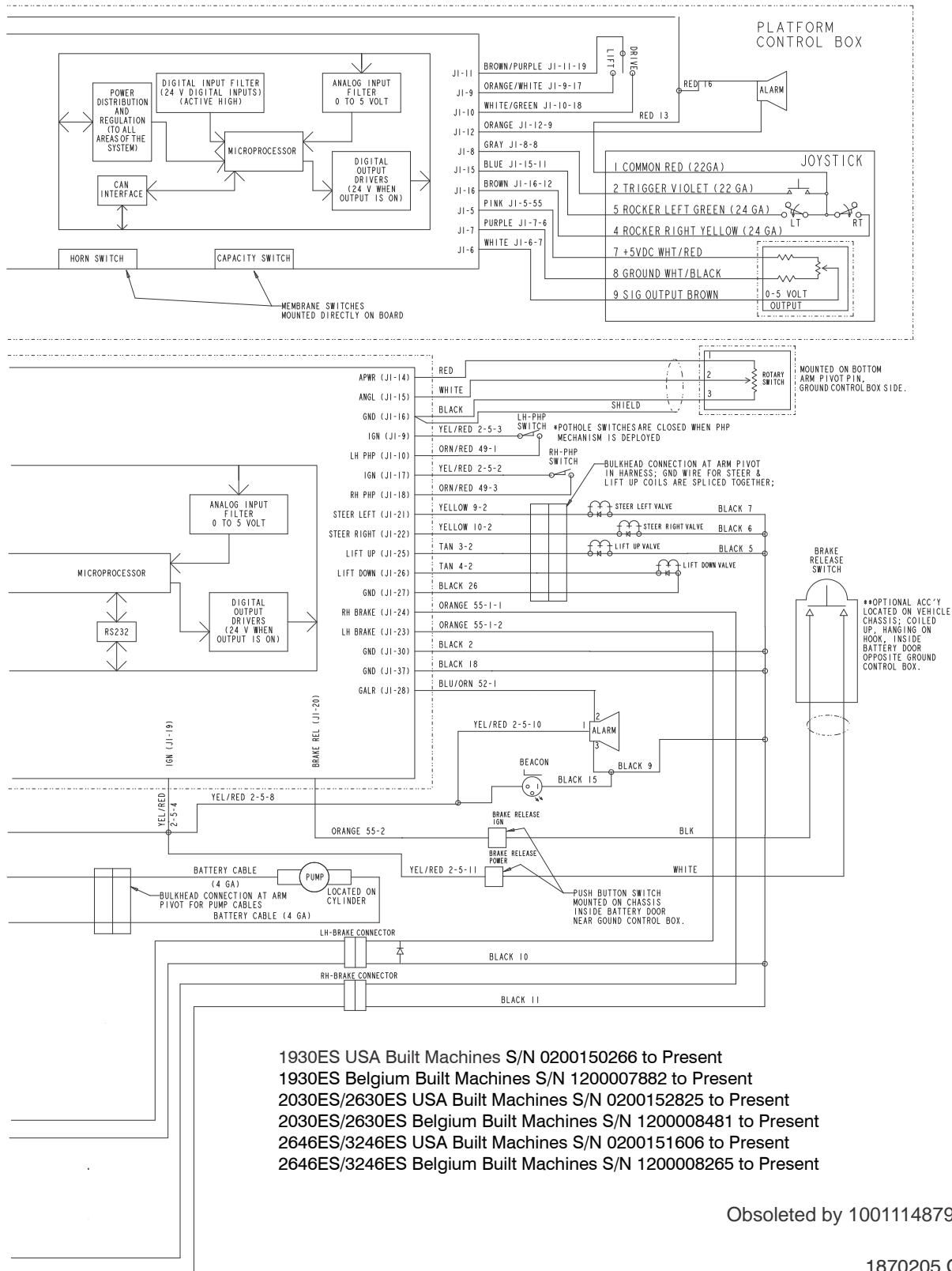


Figure 7-20. Electrical Schematic - 187205 C - Sheet 1 of 2

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



**Figure 7-21. Electrical Schematic - 187205 C - Sheet 2 of 2**

# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

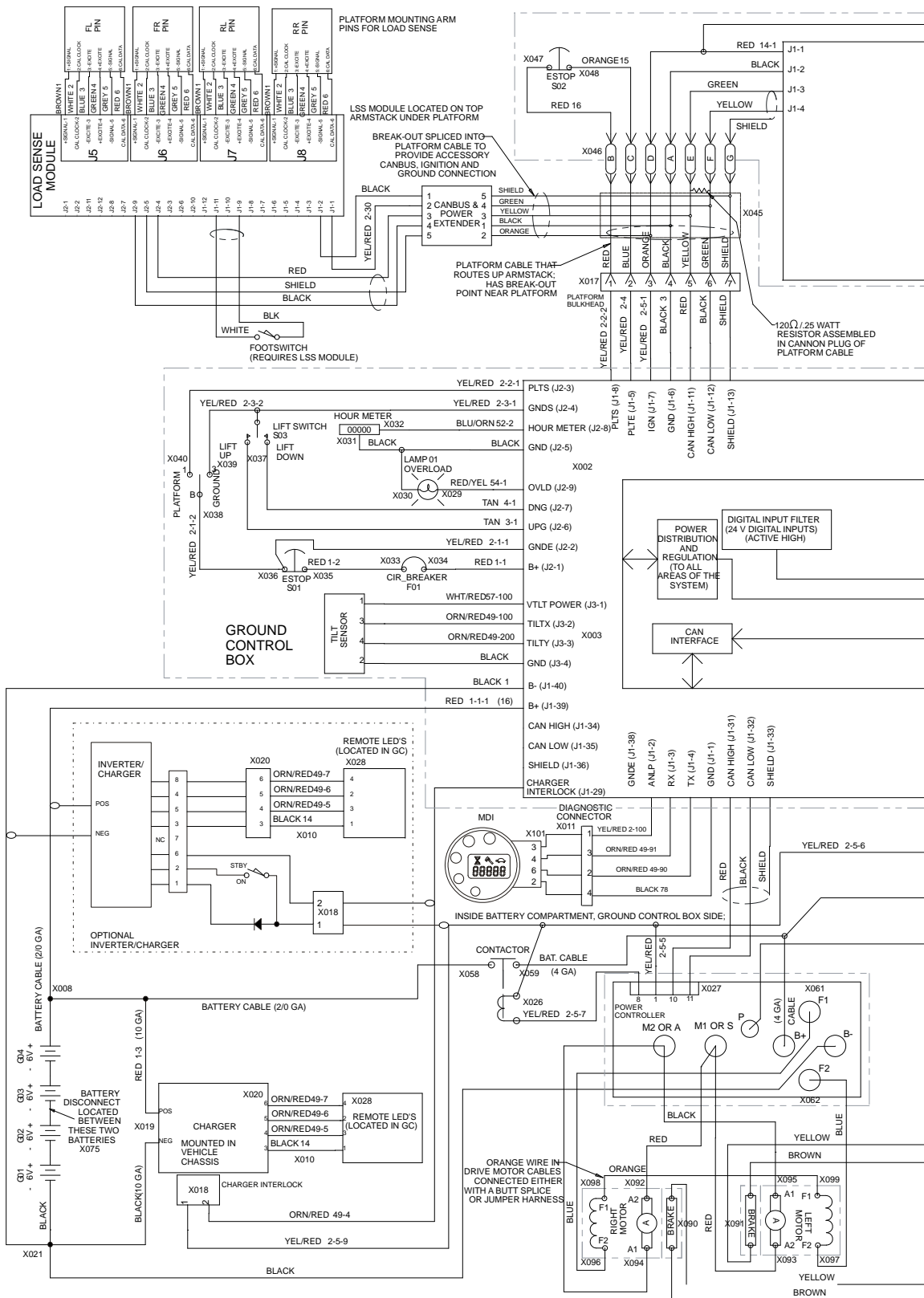
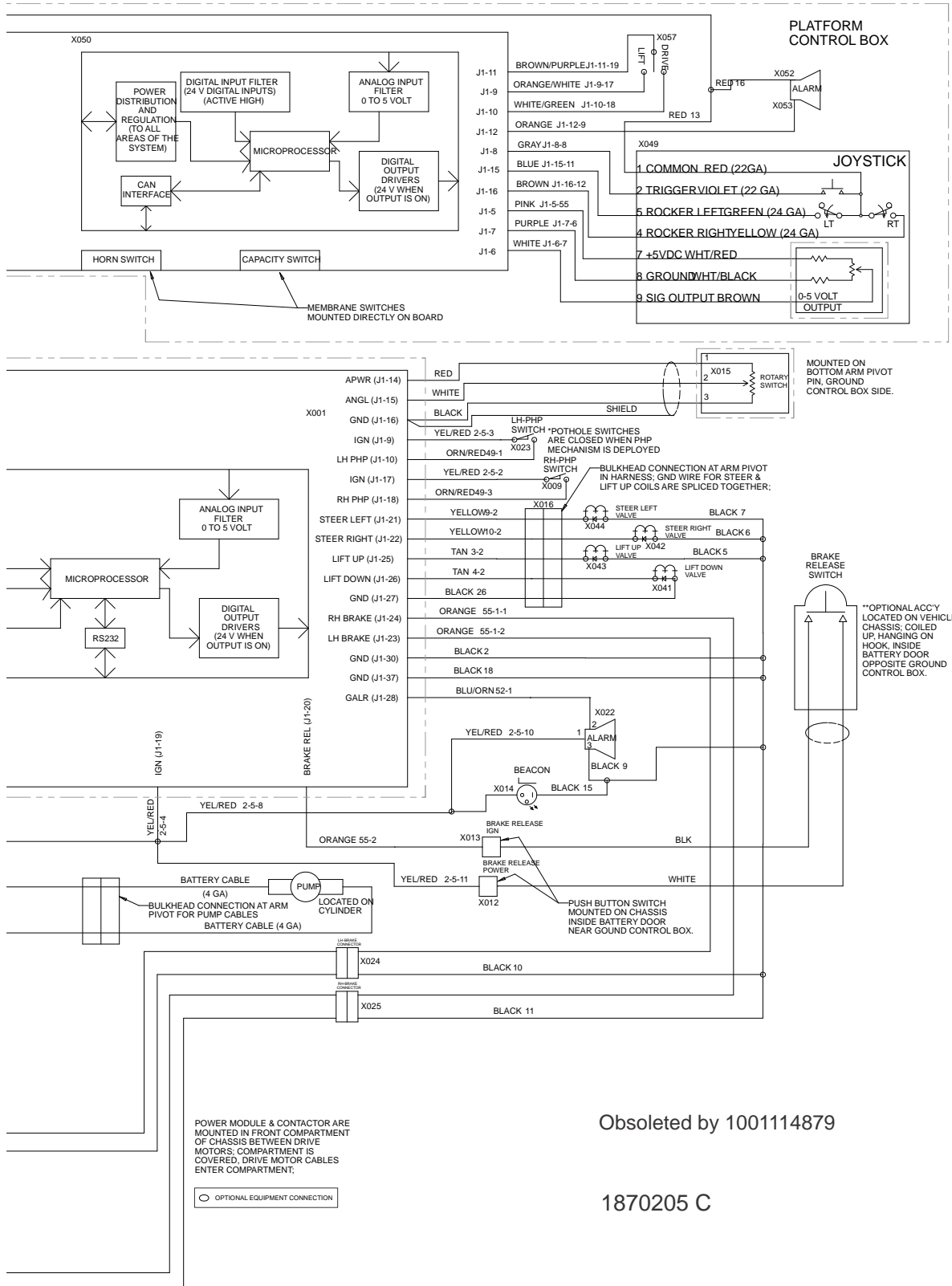


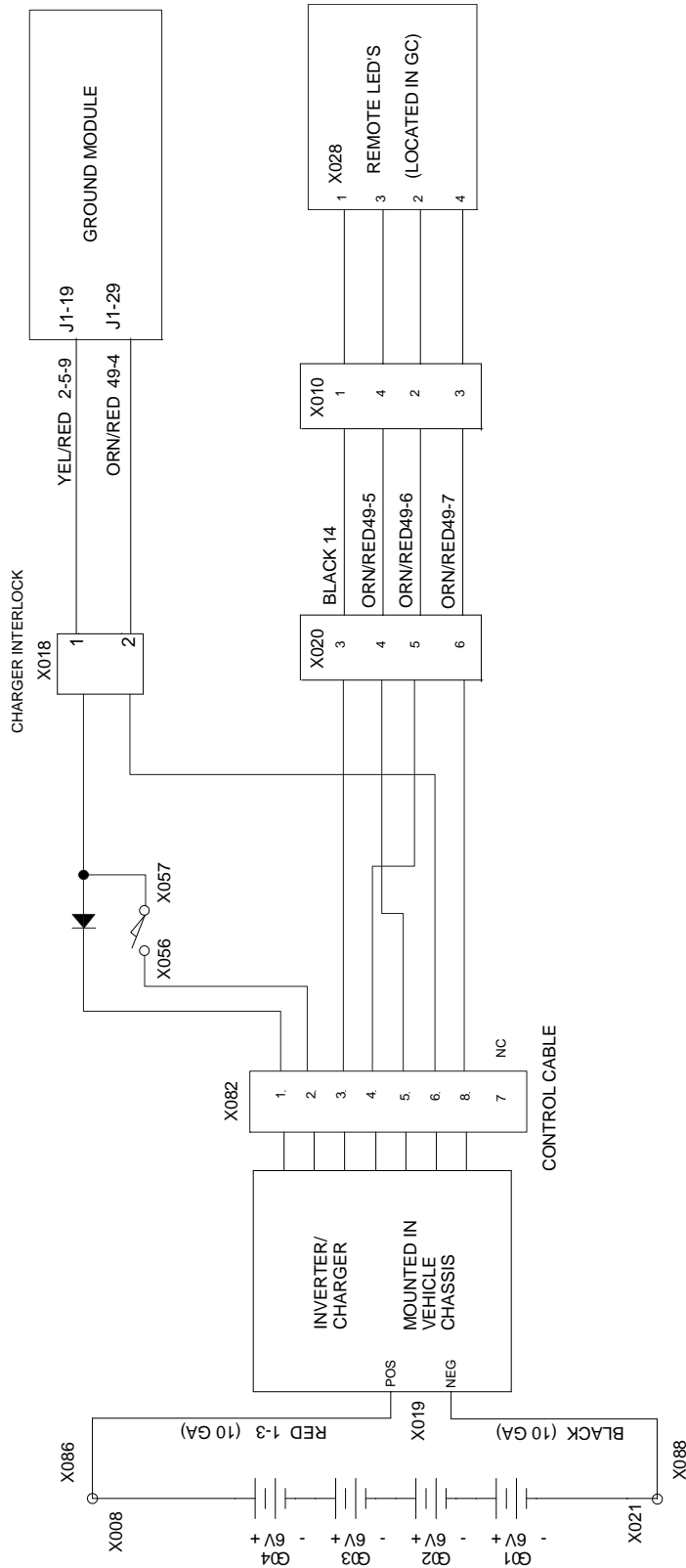
Figure 7-22. Electrical Schematic - Sheet 1 of 2 (Machines with MDI)

# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS



**Figure 7-23. Electrical Schematic - Sheet 2 of 2 (Machines with MDI)**

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



**Figure 7-24. Battery Inverter/Charger Schematic**





# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

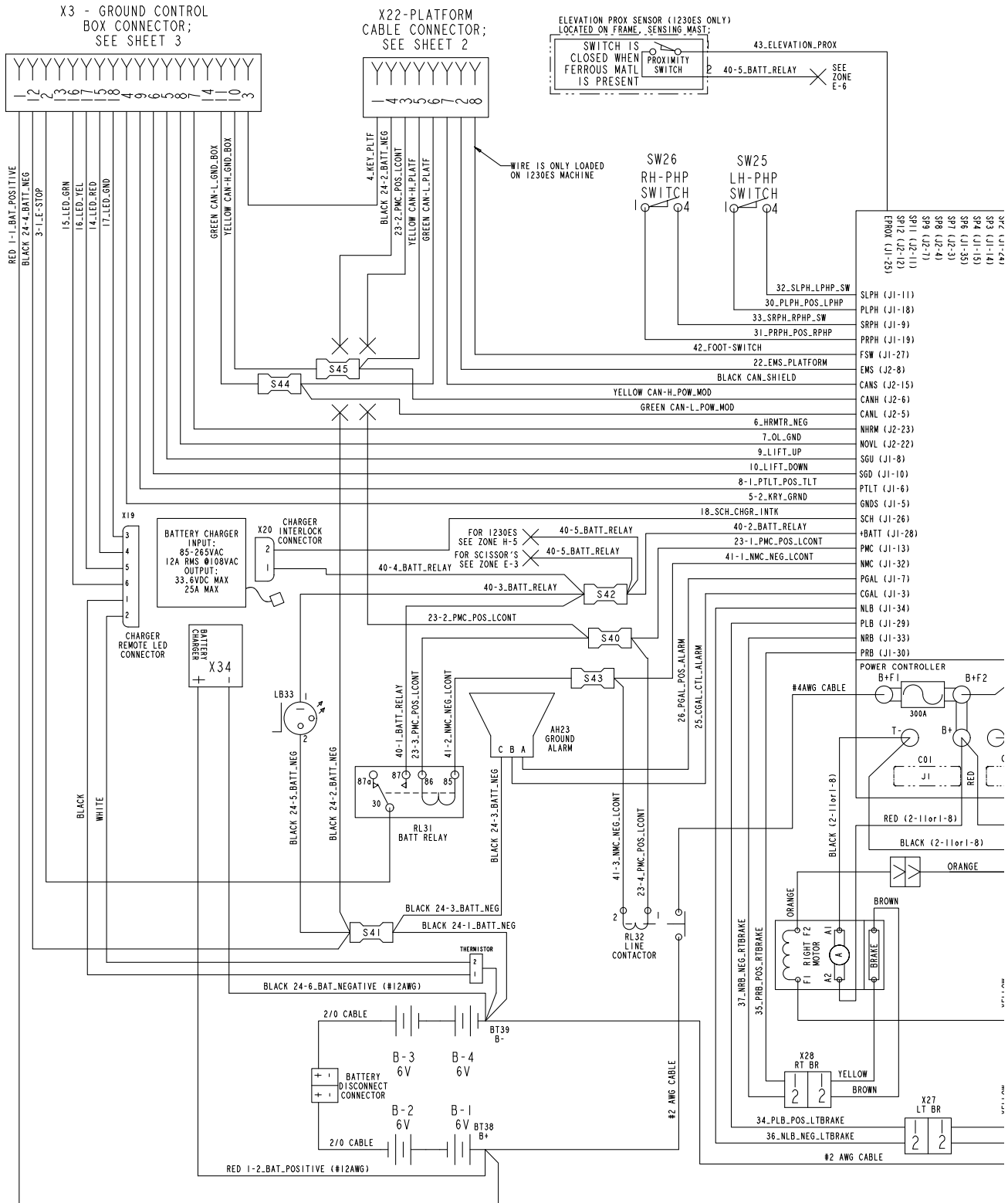
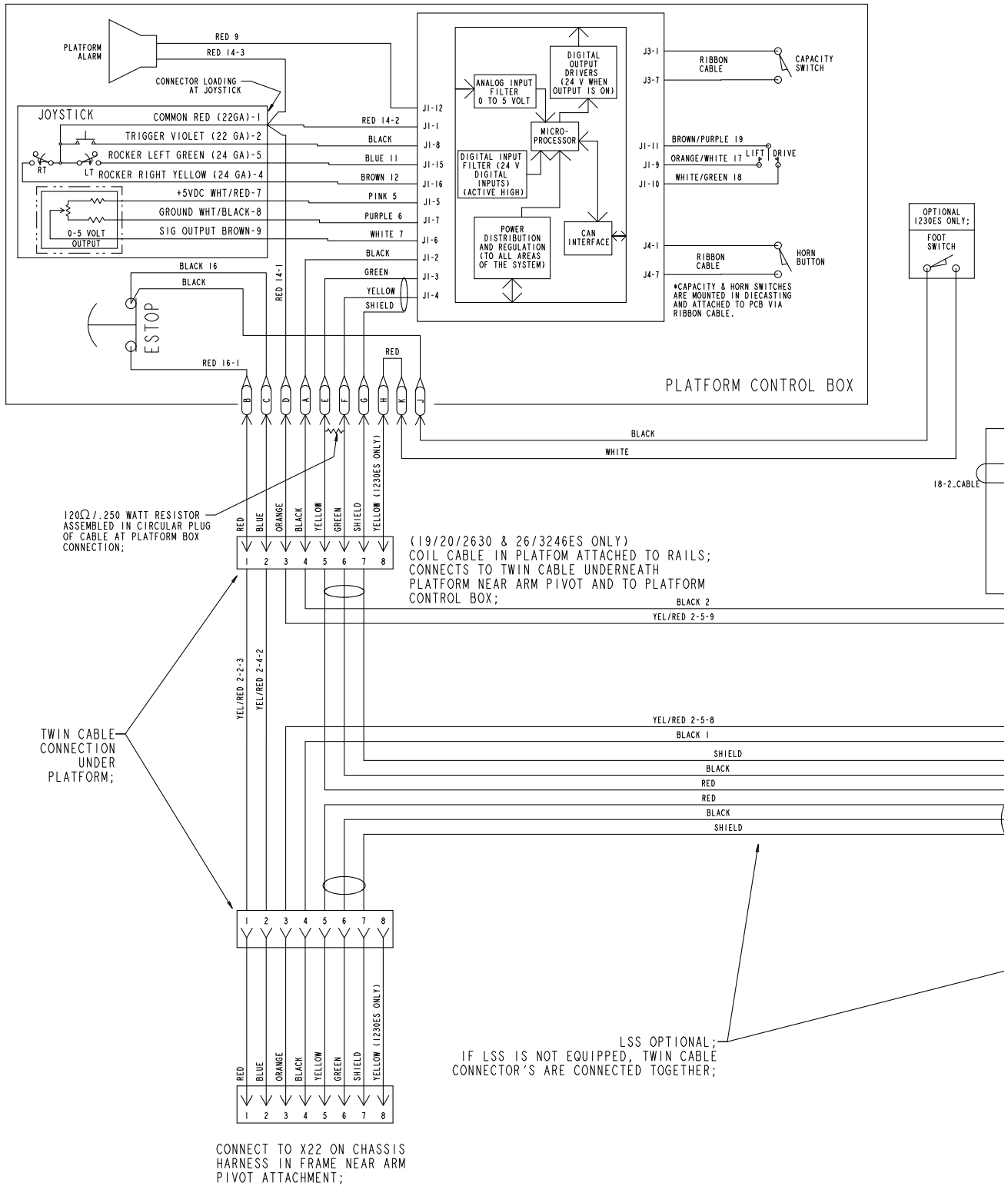


Figure 7-25. Electrical Schematic - (Machines with 1001092456 Power Module) - Sheet 1 of 3

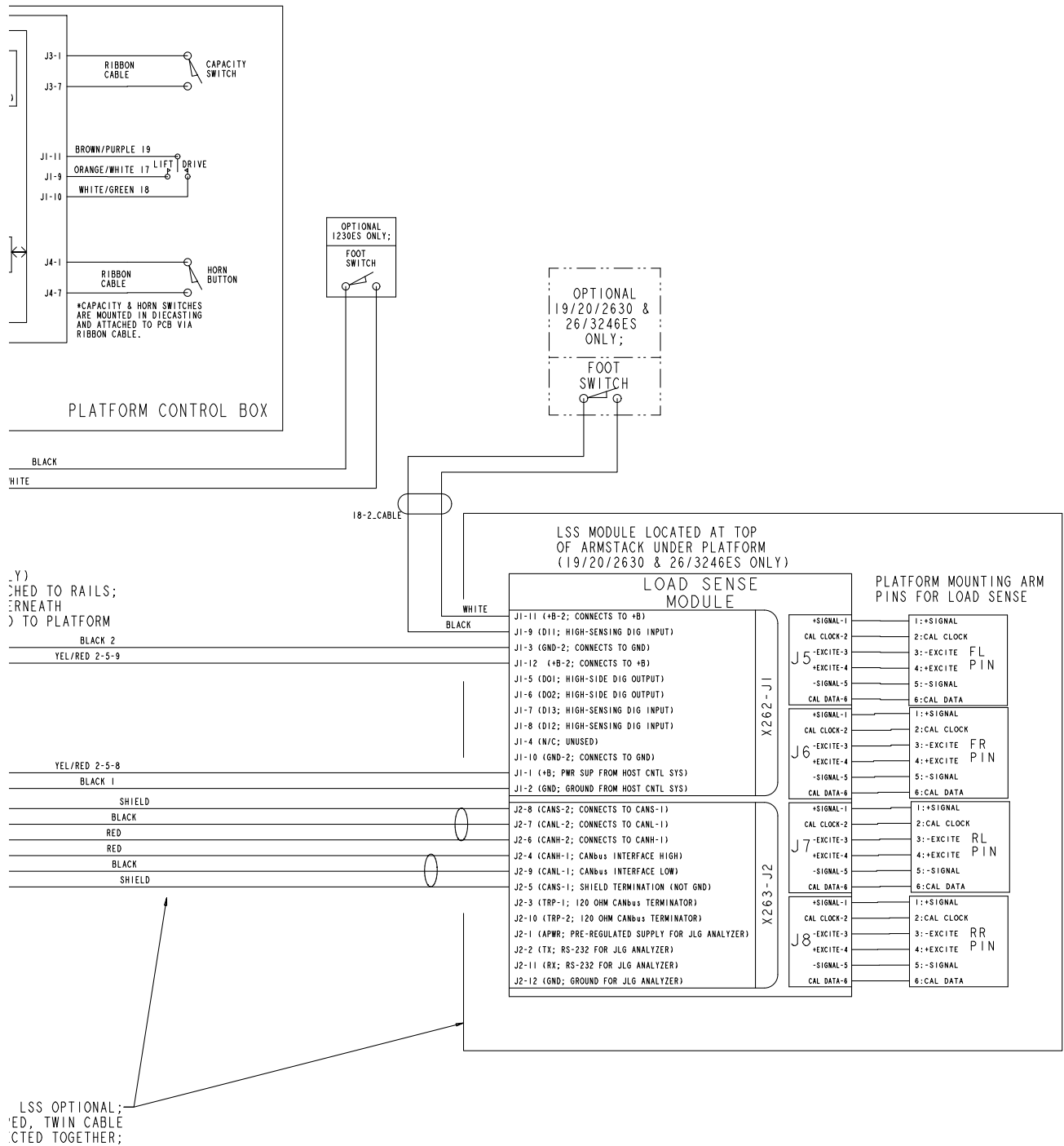


# SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS



**Figure 7-27. Electrical Schematic - (Machines with 1001092456 Power Module) - Sheet 2 of 3**

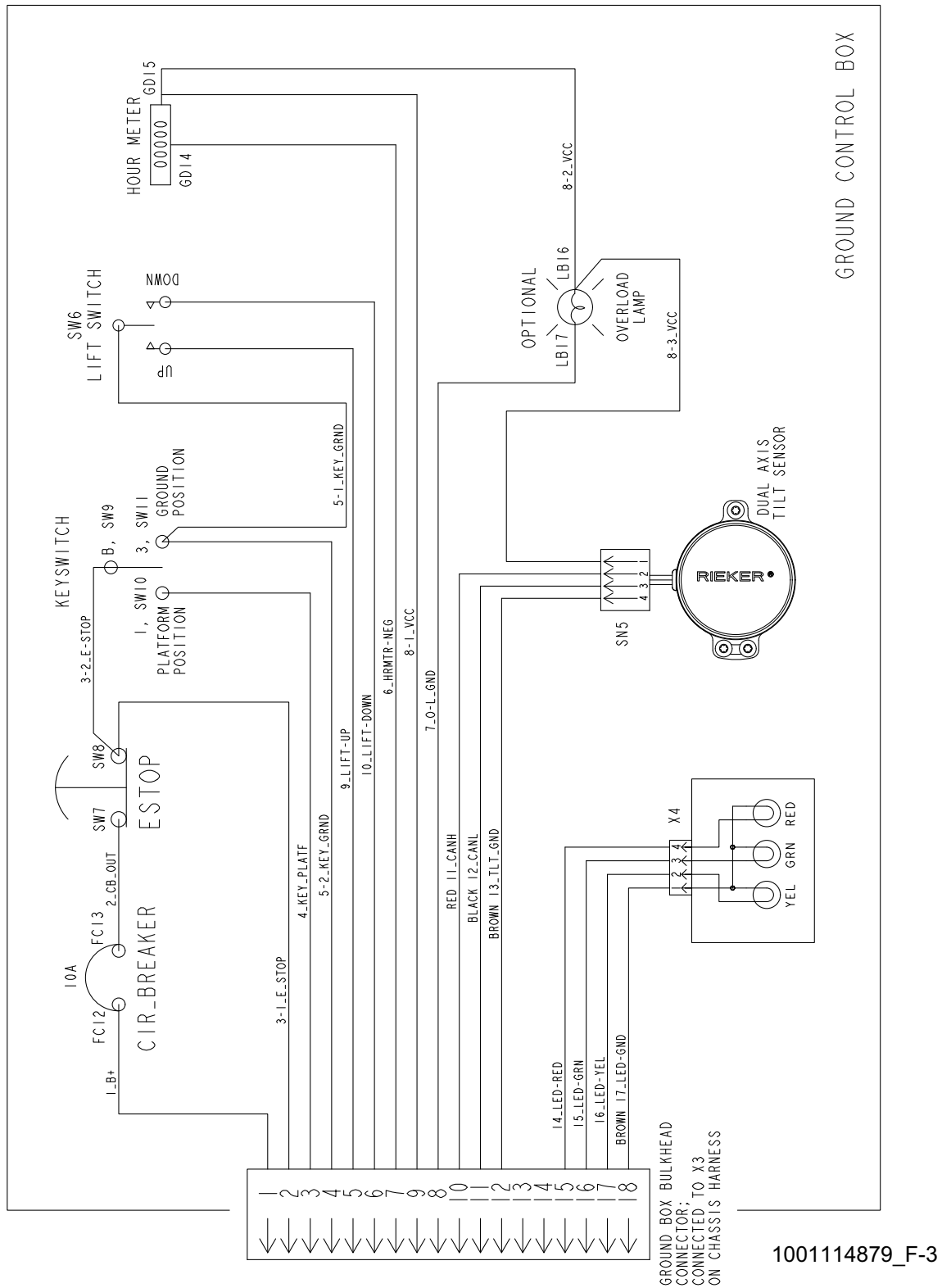
SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS



100114879\_F-2

Figure 7-28. Electrical Schematic - (Machines with 1001092456 Power Module) - Sheet 2 of 3

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



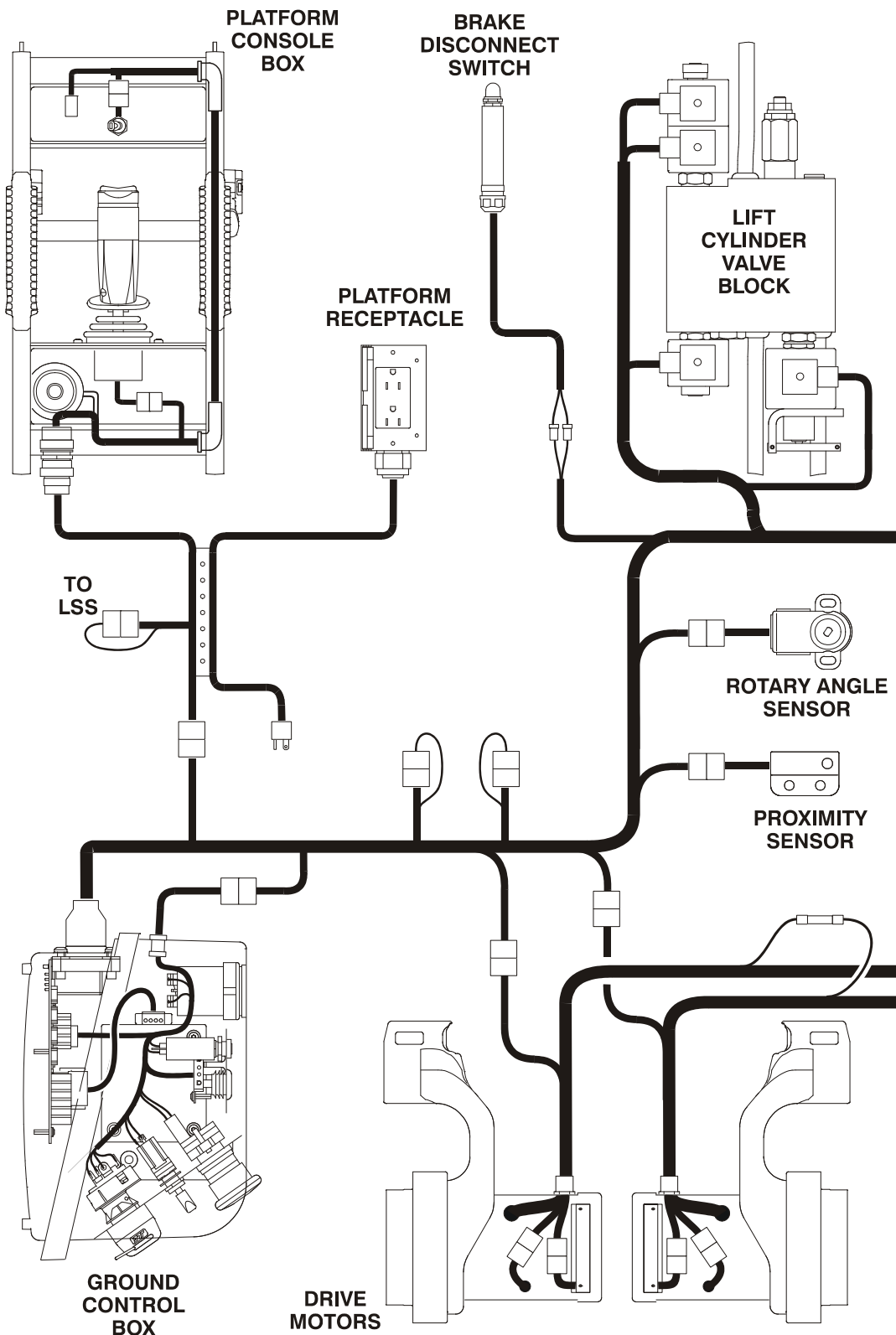
**Figure 7-29. Electrical Schematic - (Machines with 1001092456 Power Module) - Sheet 3 of 3**



**NOTES:**

A large area consisting of two columns of horizontal lines, intended for handwritten notes.

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**

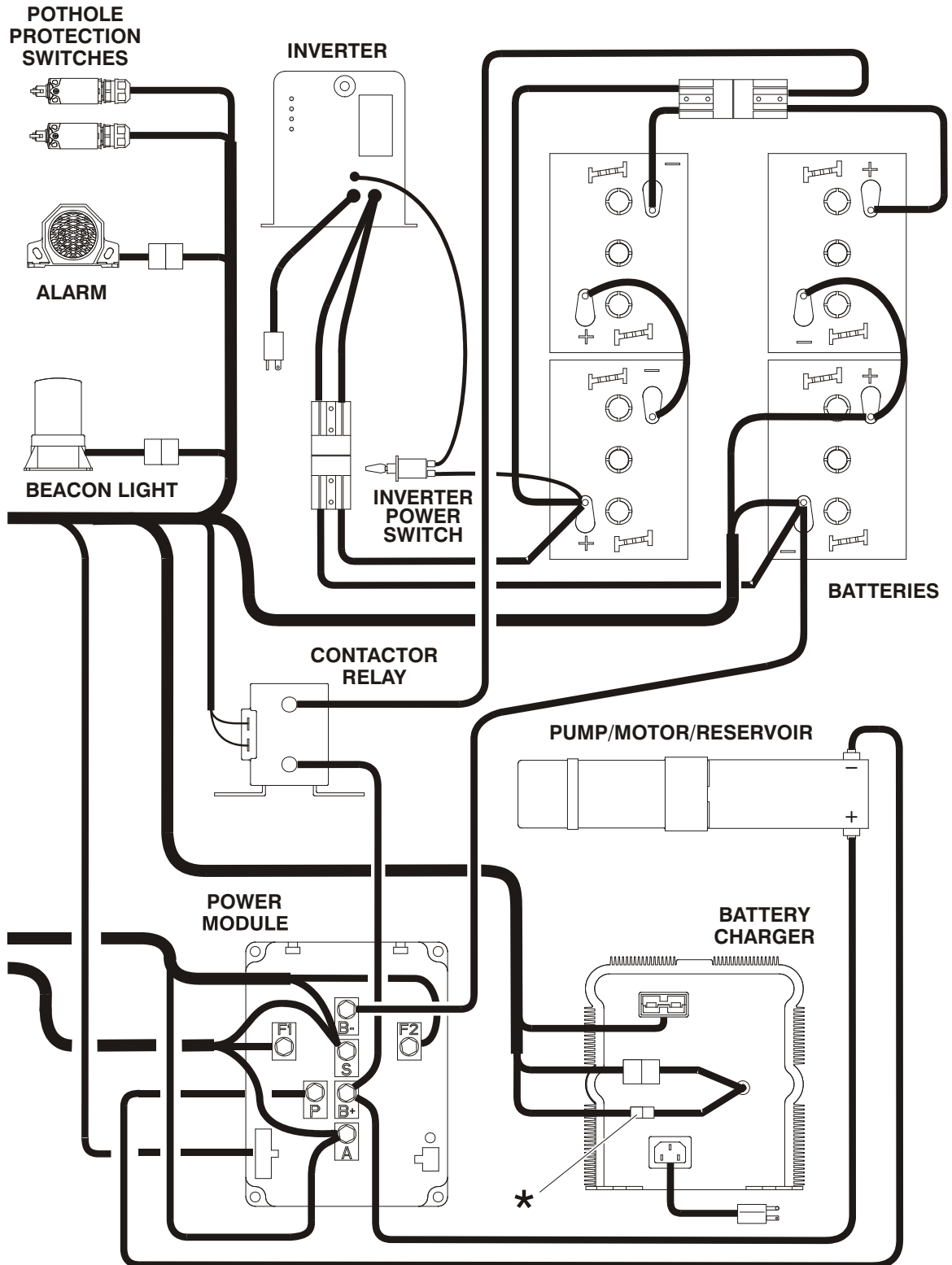


**Figure 7-30. Electrical Components - Sheet 1 of 2**

**NOTE:** (USA Built Machines Prior to S/N 0200135154) (Belgium Built Machines Prior to S/N 1200004293)



**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**

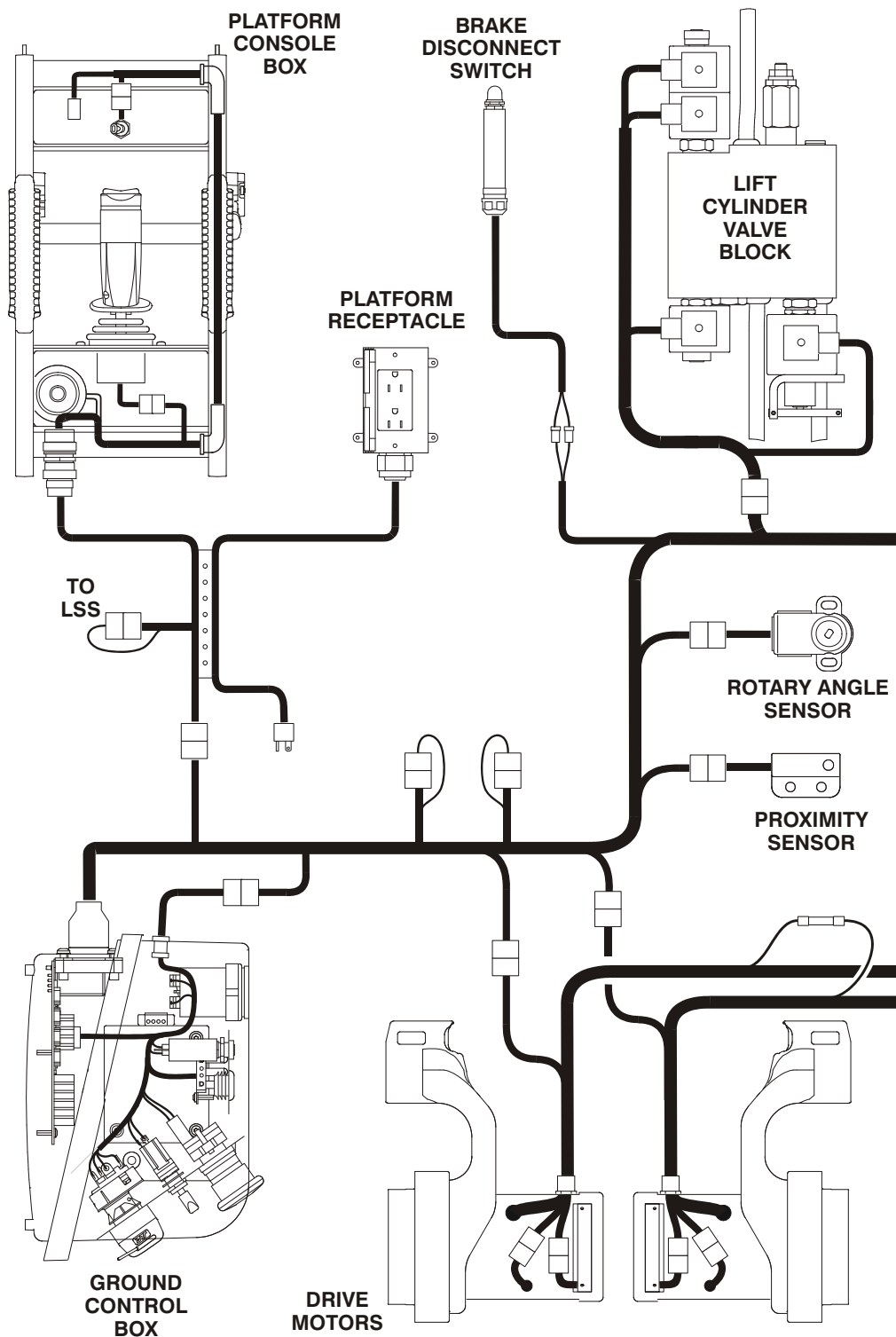


\*NOTE: THIS CONNECTION USED ONLY WHEN FOOTSWITCH OR BATTERY CHARGER INTERLOCK OPTIONS ARE REQUIRED.

**Figure 7-31. Electrical Components - Sheet 2 of 2**

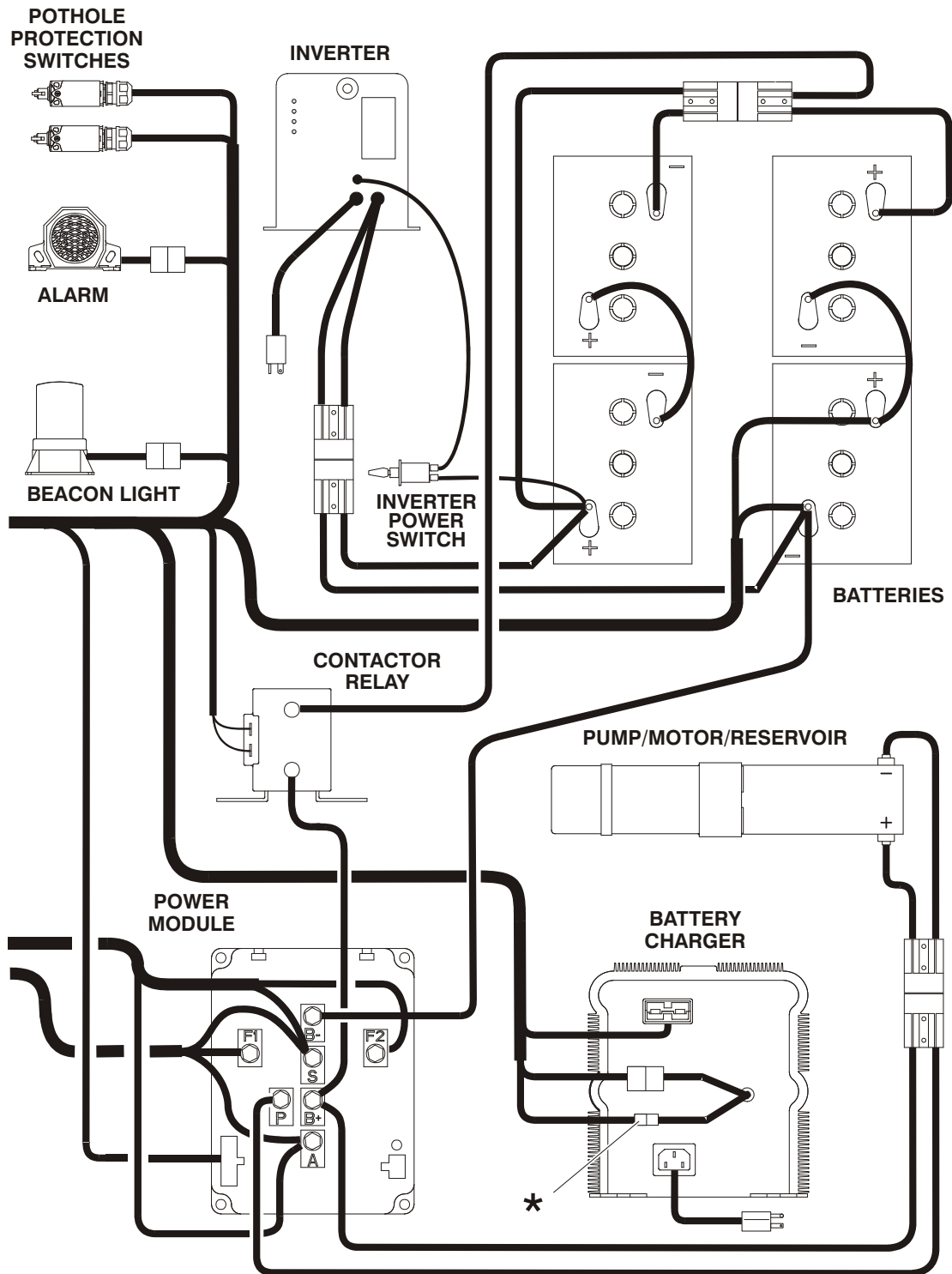
**NOTE:** (USA Built Machines Prior to S/N 0200135154) (Belgium Built Machines Prior to S/N 1200004293)

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



**Figure 7-32. Electrical Components - Sheet 1 of 2**

**NOTE:** 1930ES: USA Built Machines S/N 0200135154 to S/N 0200151266, Belgium Built Machines S/N 1200004293 to SN 1200007882; 2030ES/2630ES: USA Built Machines S/N 0200135154 to S/N 0200152528, Belgium Built Machines S/N 1200004293 to S/N 1200008481; 2646ES/3246ES: USA Built Machines S/N 0200135154 to S/N 0200151606, Belgium Built Machines S/N 1200004293 to S/N 1200008265

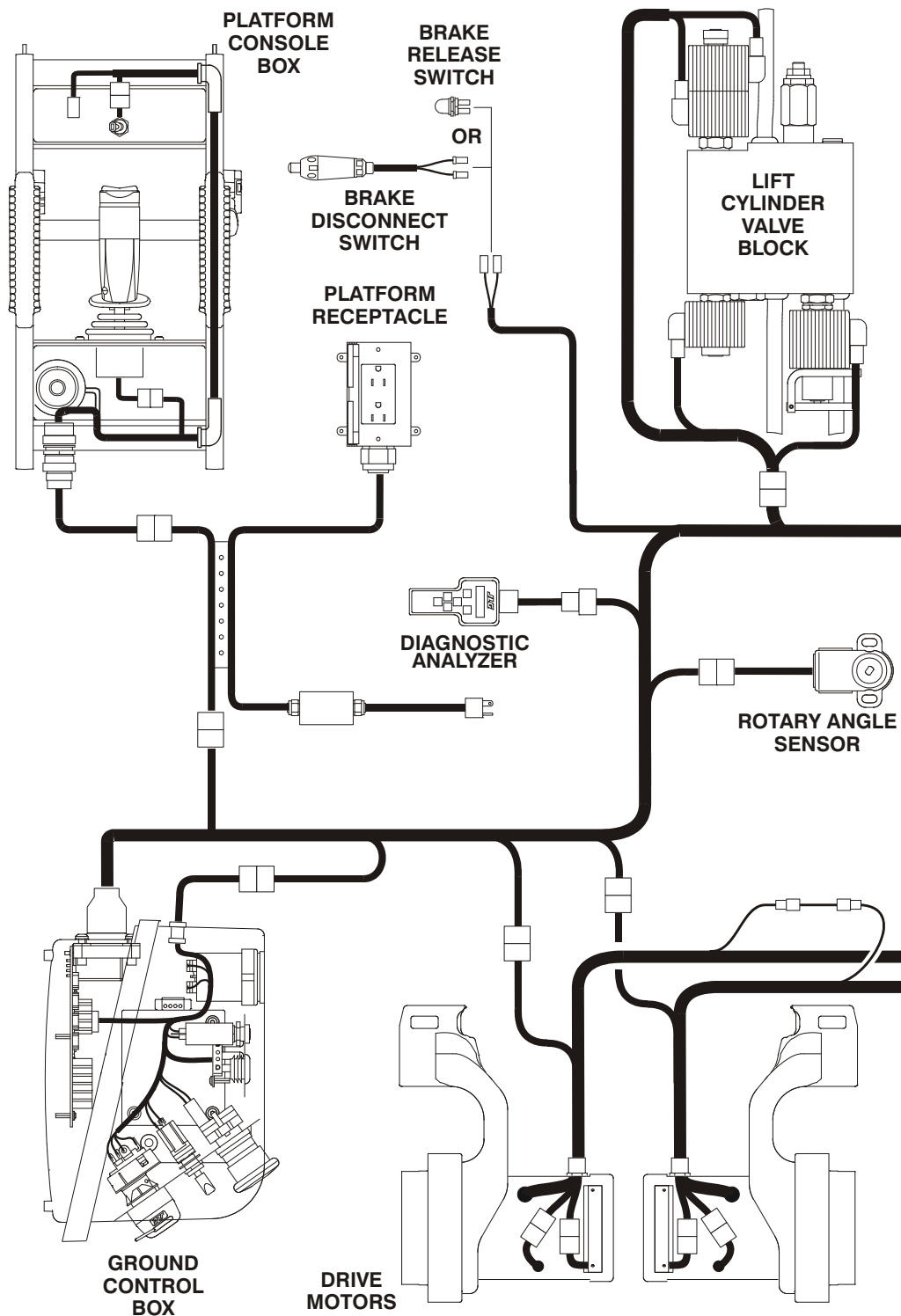


\*NOTE: THIS CONNECTION USED ONLY WHEN FOOTSWITCH OR BATTERY CHARGER INTERLOCK OPTIONS ARE REQUIRED.

Figure 7-33. Electrical Components - Sheet 2 of 2

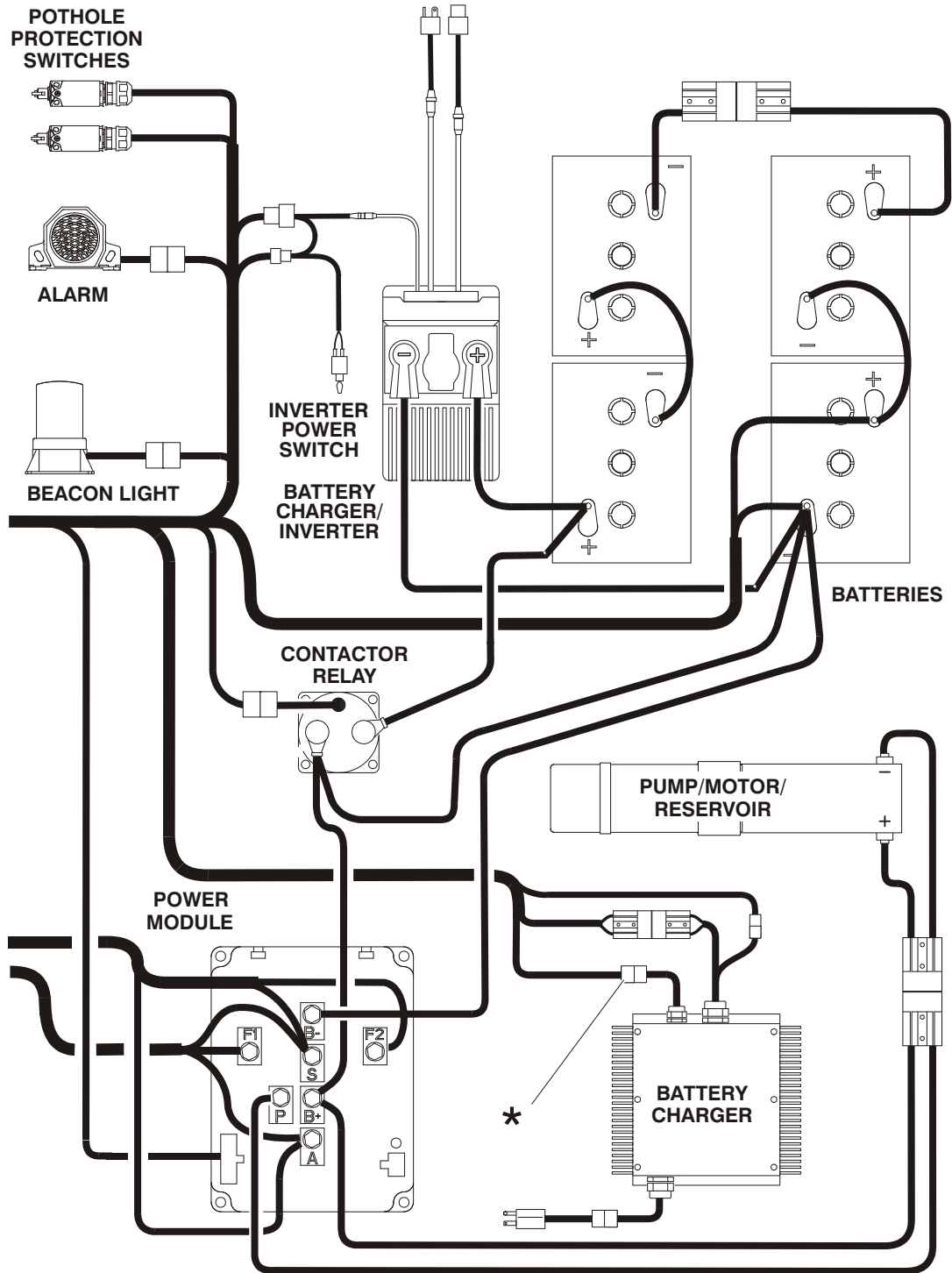
**NOTE:** 1930ES: USA Built Machines S/N 0200135154 to S/N 0200151266, Belgium Built Machines S/N 1200004293 to S/N 1200007882; 2030ES/2630ES: USA Built Machines S/N 0200135154 to S/N 0200152528, Belgium Built Machines S/N 1200004293 to S/N 1200008481; 2646ES/3246ES: USA Built Machines S/N 0200135154 to S/N 0200151606, Belgium Built Machines S/N 1200004293 to S/N 1200008265

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



**Figure 7-34. Electrical Components - Sheet 1 of 2**

**NOTE:** 1930ES: USA Built Machines S/N 0200151266 to Present, Belgium Built Machines SN 1200007882 to Present; 2030ES/2630ES: USA Built Machines S/N 0200152528 to Present, Belgium Built Machines S/N 1200008481 to Present; 2646ES/3246ES: USA Built Machines S/N 0200151606 to Present, Belgium Built Machines S/N 11200008265 to Present

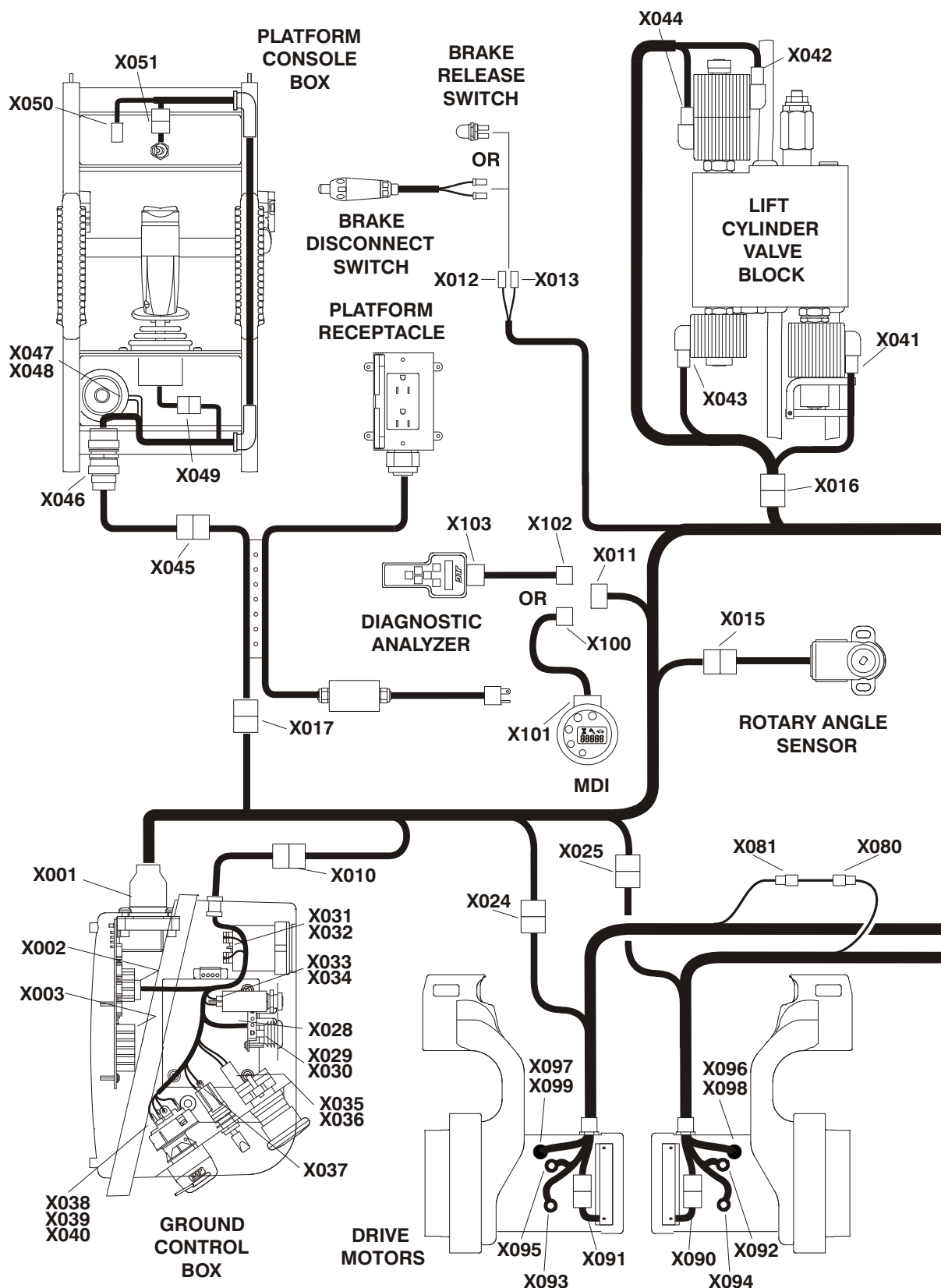


\*NOTE: THIS CONNECTION USED ONLY WHEN FOOTSWITCH OR BATTERY CHARGER INTERLOCK OPTIONS ARE REQUIRED.

Figure 7-35. Electrical Components - Sheet 2 of 2

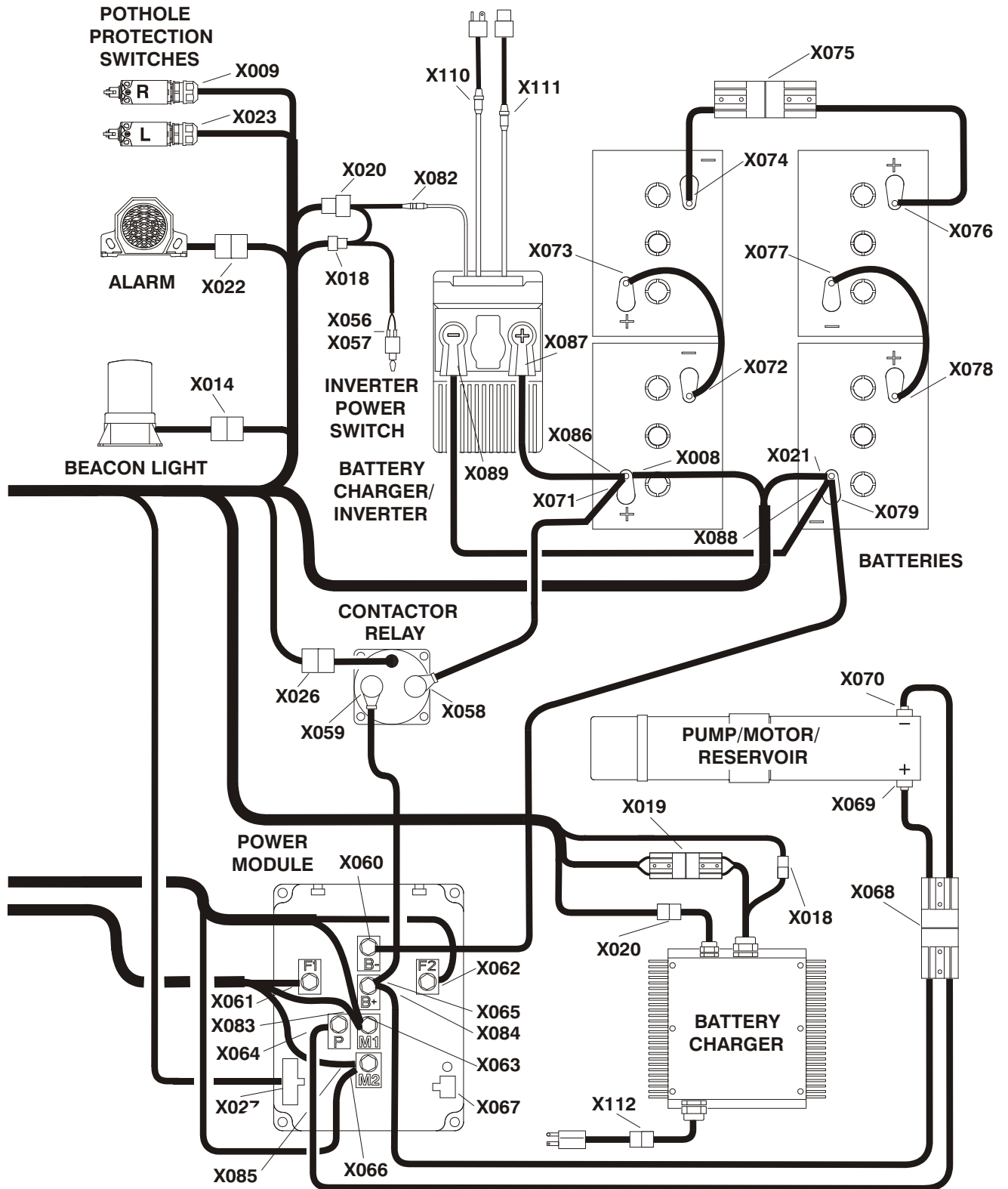
**NOTE:** 1930ES: USA Built Machines S/N 0200151266 to Present, Belgium Built Machines SN 1200007882 to Present; 2030ES/2630ES: USA Built Machines S/N 0200152528 to Present, Belgium Built Machines S/N 1200008481 to Present; 2646ES/3246ES: USA Built Machines S/N 0200151606 to Present, Belgium Built Machines S/N 11200008265 to Present

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**



**Figure 7-36. Electrical Components - Sheet 1 of 2 (Machines with MDI)**

SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS

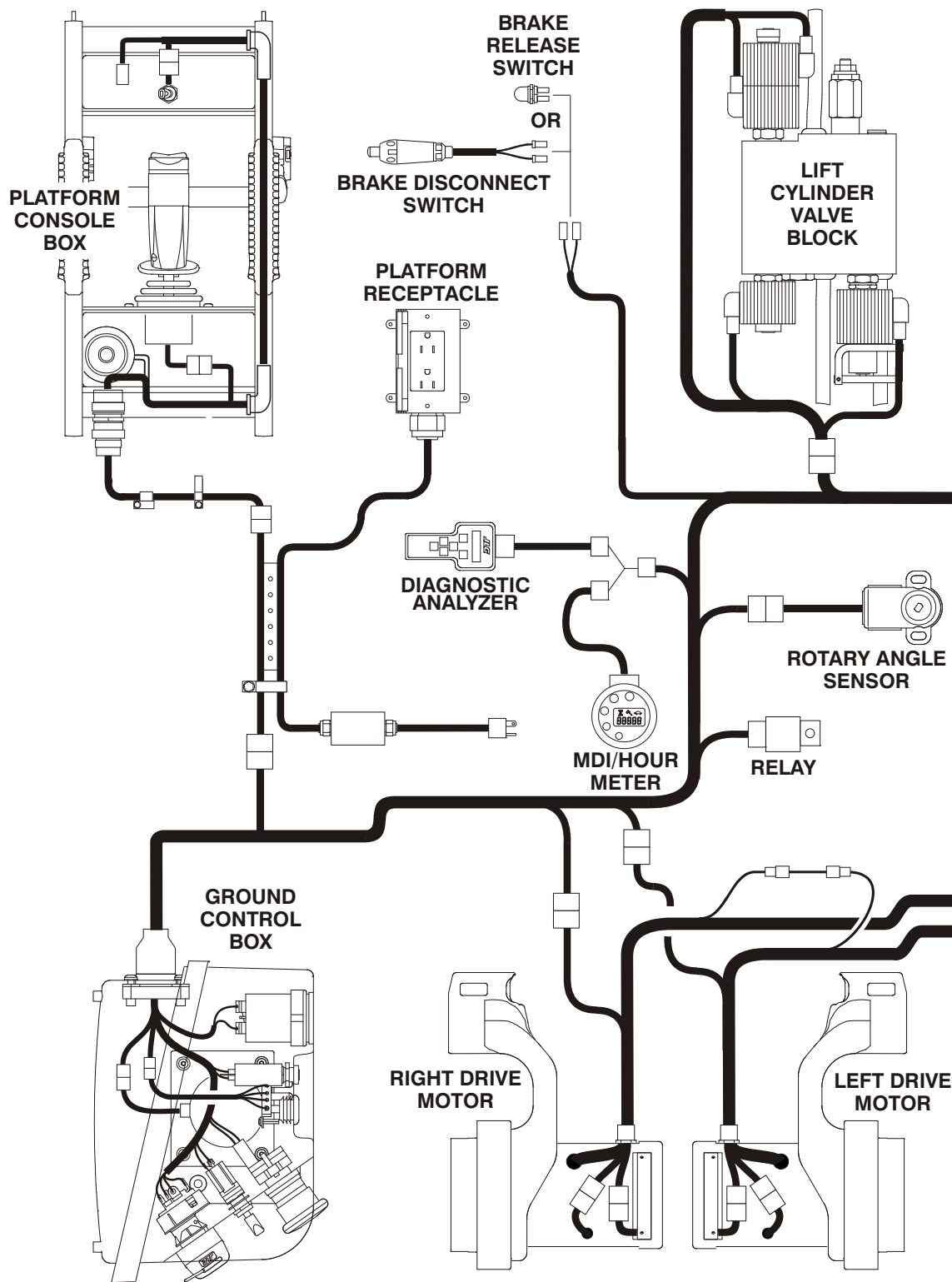


\*NOTE: THIS CONNECTION USED ONLY WHEN FOOTSWITCH OR BATTERY CHARGER INTERLOCK OPTIONS ARE REQUIRED

Figure 7-37. Electrical Components - Sheet 2 of 2 (Machines with MDI)

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**

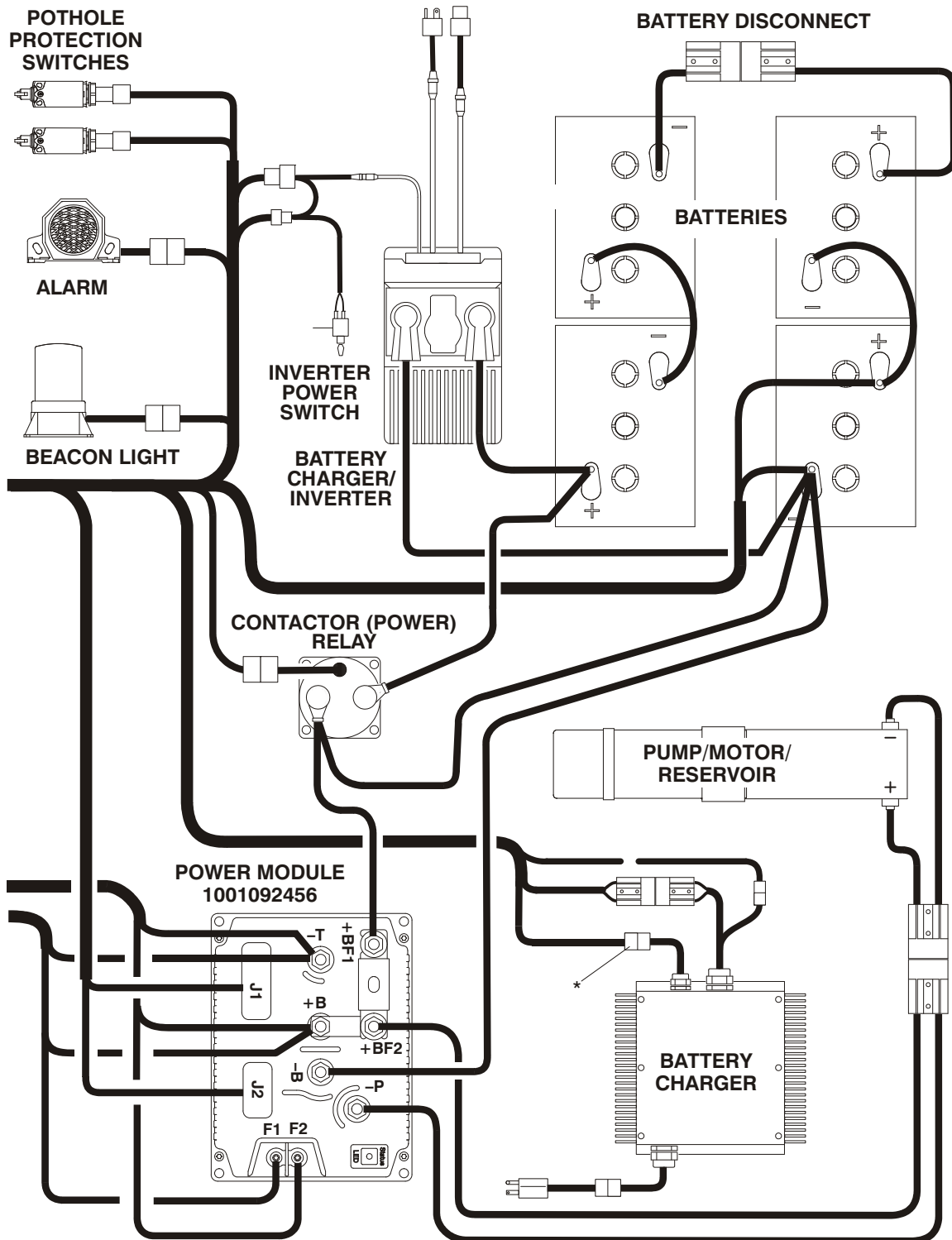
**NOTE: THIS ILLUSTRATION USED WITH 1001092456 POWER MODULE.**



**Figure 7-38. Electrical Components - (Machines with 1001092456 Power Module) - Sheet 1 of 2**



NOTE: THIS ILLUSTRATION USED WITH 1001092456 POWER MODULE.



\* NOTE: THIS CONNECTION USED ONLY WHEN FOOTSWITCH OR BATTERY CHARGER INTERLOCK OPTIONS ARE REQUIRED.

Figure 7-39. Electrical Components - (Machines with 1001092456 Power Module) - Sheet 2 of 2

7.8 HYDRAULIC SCHEMATIC

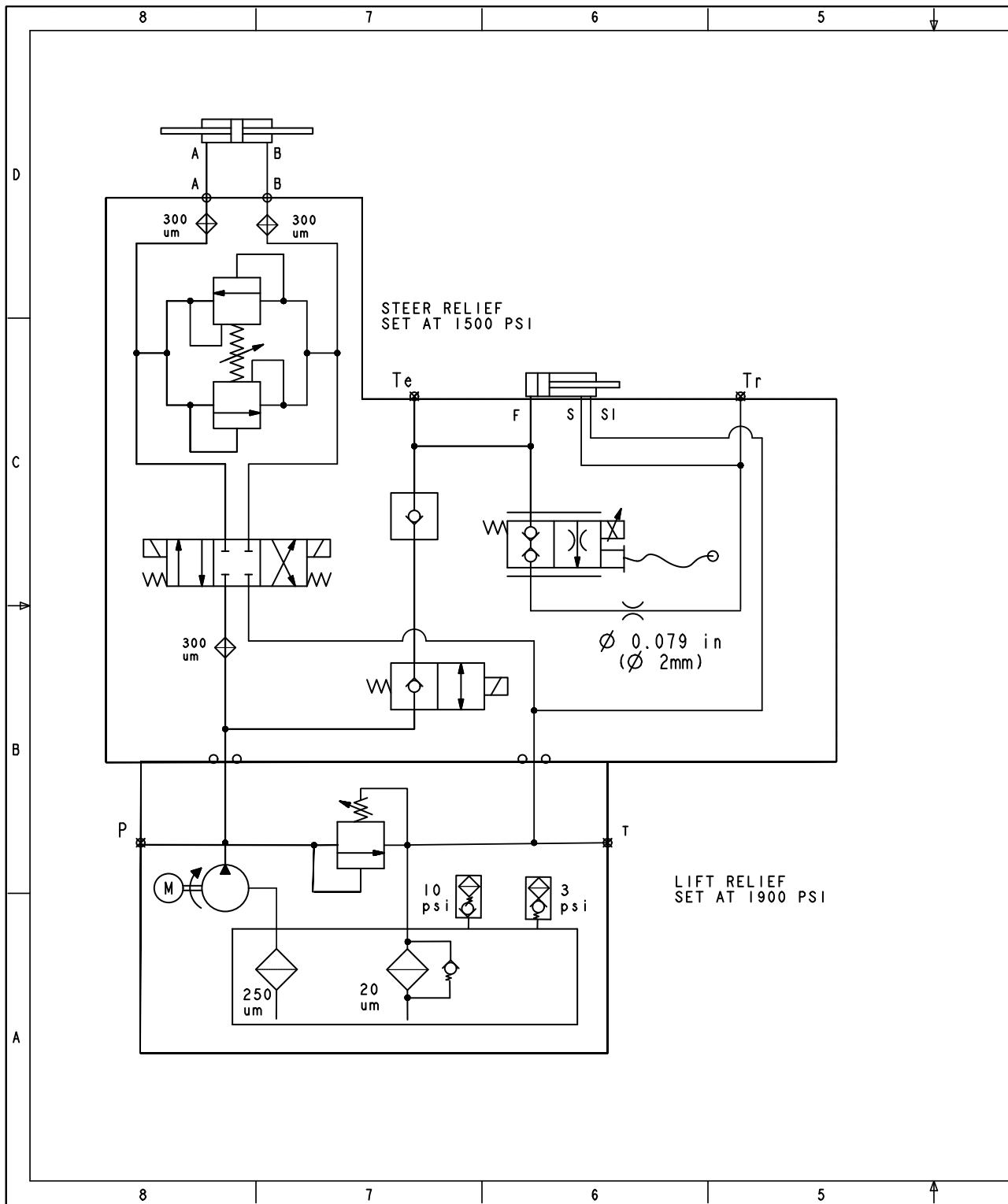


Figure 7-40. Hydraulic Schematic (Sht. 1 of 2)

**SECTION 7 - GENERAL ELECTRICAL INFORMATION & SCHEMATICS**

	4	3	2	1	
MODEL	1930ES	2030ES	2630ES	2646ES	3246ES
PUMP SIZE	3.2 CC	3.2 CC	3.2 CC	3.2 CC	3.2 CC
LIFT CYLINDER, BARREL, MM	70 MM 3848 SQ MM	80 MM 5026 SQ MM	80 MM 5026 SQ MM	100 MM 7854 SQ MM	100 MM 7854 SQ MM
LIFT CYLINDER BARREL, IN	2.75 IN 5.94 SQ IN	3.14 IN 7.74 SQ IN	3.14 IN 7.74 SQ IN	3.94 IN 12.19 SQ IN	3.94 IN 12.19 SQ IN
LIFT CYLINDER, ROD, MM	45 MM 1590 SQ MM	55 MM 2376 SQ MM	55 MM 2376 SQ MM	60 MM 2827 SQ MM	60 MM 2827 SQ MM
LIFT CYLINDER ROD, IN	1.77 IN 2.46 SQ IN	2.17 IN 3.70 SQ IN	2.17 IN 3.70 SQ IN	2.37 IN 4.38 SQ IN	2.37 IN 4.38 SQ IN
LIFT CYL. STROKE, MM	1097	1222	1222	1140	1443
LIFT CYL. STROKE, INCHES	43.19	48.11	48.11	44.91	56.81
LIFT CYL. ANNULUS, SQ MM	2258	2650	2650	5026	5026
LIFT CYL. ANNULUS, SQ. IN.	3.50	4.11	4.11	7.79	7.79
STEER CYLINDER, BARREL, MM	50 MM 1963 SQ MM	50 MM 1963 SQ MM	50 MM 1963 SQ MM	60 MM 2827 SQ MM	60 MM 2827 SQ MM
STEER CYLINDER, BARREL, IN	1.97 IN 3.04 SQ IN	1.97 IN 3.04 SQ IN	1.97 IN 3.04 SQ IN	2.36 IN 4.38 SQ IN	2.36 IN 4.38 SQ IN
STEER CYLINDER, ROD, MM	35 MM 962 SQ MM	35 MM 962 SQ MM	35 MM 962 SQ MM	35 MM 962 SQ MM	35 MM 962 SQ MM
STEER CYLINDER, ROD, IN	1.38 IN 1.49 SQ IN	1.38 IN 1.49 SQ IN	1.38 IN 1.49 SQ IN	1.38 IN 1.49 SQ IN	1.38 IN 1.49 SQ IN
STEER CYL STROKE, MM	80 L - 80 R	80L -80R	80L - 80R	79L - 79R	79L -79R
STEER CYL STROKE, INCHES	6.30	6.30	6.30	6.22	6.22
STEER CYL ANNULUS, SQ MM	1001	1001	1001	1865	1865
STEER CYL. ANNULUS, SQ IN	1.55	1.55	1.55	2.89	2.89
LIFT RELIEF SETTING PRODUCTION	1900	1900	1900	1900	1900

HYDRAULIC CIRCUIT REFERS TO ES SCISSOR LIFT CYLINDER ASSEMBLY

UNLESS OTHERWISE SPECIFIED, ALL  
DIMENSIONS ARE IN MILLIMETERS.

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Figure 7-40. Hydraulic Schematic (Sht. 2 of 2)

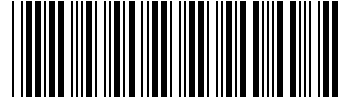


**CALIFORNIAN PROPOSITION 65**  
**BATTERY WARNING**

**Battery posts, terminals  
and related accessories  
contain lead and lead  
compounds, chemicals  
known to the State of  
California to cause cancer  
and reproductive harm.**

**Batteries also contain other  
harmful chemicals known  
to the State of California.**

**WASH HANDS  
AFTER HANDLING!**



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